Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

Old Series Vol. 21 FEBRUARY, 1908 New Series Vol. 1, No. 4

THE CAP ROUGE TRESTLE

D. C. TENNANT, B. A. Sc., '99.

Cap Rouge is a small town, situated at the mouth of Cap Rouge River, on the north shore of the St. Lawrence, about ten miles west of Quebec. The ravine formed by the mouth of Cap Rouge River is about three-quarters of a mile wide and two hundred feet deep and is fairly flat. The line of the National Transcontinental Railway from the Quebec Bridge westerly is to cross the mouth of the valley parallel to the St. Lawrence, the track being elevated about one hundred and fifty feet above the ground at the deepest part of the ravine. This necessitates a steel trestle. Preliminary plans were prepared and tenders called for by the Commissioners of the Transcontinental Railway at Ottawa. Messrs. M. Pond and J. T. Davies, of Ottawa, were awarded the contract for the substructure and the Dominion Bridge Co., of Montreal, the contract for the superstructure. Plans showing the proposed design were submitted by the Bridge Company with their tender.

The trestle was designed in accordance with Dominion Government specifications of 1905, using the live load class "heavy," which provides for two 180-ton locomotives, each 48 feet long, followed by a uniform load of 4,750 pounds per lineal foot of track. Allowance is made for impact and vibration by adding to the sum of the dead and live loads, an increment found by the formula.

$$\frac{LL^2}{DL + LL}$$

where LL = the live load stress and DL = the dead load stress, wind was taken at 30 pounds per square foot of exposed surface.

The line is single track, and where it crosses Cap Rouge valley it is level and on a tangent. As will be seen from the diagram, Fig. 1, the east slope of the ravine is abrupt and about six hundred and fifty feet from the east end of the trestle the line crosses the river, which at this point is over three hundred

feet wide. From the river to the west side the ground is fairly level and the west slope of the ravine is gradual. The greater part of the track is supported on braced towers, forty feet, centre to centre of bents longitudinally. These towers support forty-foot girder spans directly over them and forming the longitudinal top strut of the towers, and intervening sixty-foot girder spans. At the eastern escarpment it was deemed advisable on account of the steep slope of the ground and consequent danger of foundations being washed away in spring time not to build any piers on the face of the slope, so a one hundred and twenty-five foot deck truss span was used, one end resting on a short bent at the top of the cliff and the other end on a long bent, with its base at the bottom. The building of piers in the river was found expensive, so a one hundred and sixty foot deck truss span and a one hundred and fifty foot span were used, the ends of these resting on bents. Thus only two river piers were necessary, one under each bent supporting truss spans as shown in Fig. 1. The bents are numbered beginning from the east end, this being the direction in which the line was chained. Bents number twelve and thirteen in the original design came in place between bents eleven and fourteen, but owing to difficulty in getting foundations, the design was changed, using a truss span, thus lessening the number of bents.

In this paper there is room for only a word about the foundations. The substratum is a shaley gravel and this is covered with a variable thickness of muddy clay—the kind that sticks. In the river bed there are also some layers of sand and silt. Considerable difficulty was experienced in obtaining a good foundation in the river and caisson work was finally used. In other places a solid foundation was easily available. All piers were built of concrete.

The bridge flooring is a modification of the ordinary Dominion Government floor and is shown in Fig. 2. On account of the height and length of the trestle it was thought best to lay a board walk on the ties outside the outer guard rail and to have a hand railing on the bridge. To this end the ties were made sixteen feet long and arranged to cantilever alternately on opposite sides of the bridge to carry the planking and the posts for railing. The ties are 10 x 14 inches, white pine, spaced 14 inches, centre to centre, longitudinally and notched one-half inch over the girders. The posts of the hand rail are spaced 9 feet 4 inches apart, one resting on every fourth projecting tie. The inner guard is an ordinary rail spiked to the ties and the outer guard is 8 x 9 inches, white pine, bolted to every fourth tie with 3-4 inch bolts. At four points on the trestle the deck and handrail are to have a side extension to allow for the stowing of a hand car in case it is overtaken by a train.

The 40-foot and 60-foot plate girders were made the same

depth—6 feet 1-2 inch, back to back of flange angles. In order to avoid complications in clapping the ties no cover plates were used on the top flanges. The forty-foot girders were composed of 72 x 3-8 webs and 2-8 x 8 x $\frac{11}{16}$ angles in each flange. For sixty-foot girders the same size of web was used, the top flange being made of 2, 8 x 8 x 3-4 angles and 2, 6 x 6 x 3-4 angles as shown in Fig. 2, and the bottom flange of 2, 8 x 8 x 3-4 angles and 2, 17 inches x 9-16 inch cover plates. The girders were spaced 9 feet 0 inches apart, centre to centre, and connected across every twelve or thirteen feet by brace frames. The sixty-foot girder spans have both top and bottom lateral systems, but bottom laterals were omitted on the forty-foot spans. One end of each sixty-foot span is allowed to slide on top of the supporting bent, thus making an expansion joint every 100 feet as shown in Fig. 1.

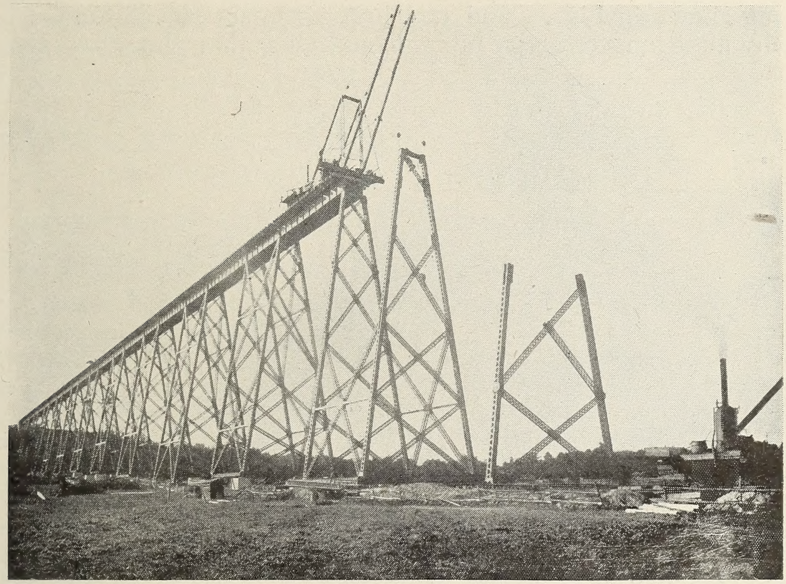


Fig. 4—Erection of Bents 41 and 42.

The 125-foot, 150-foot, and 160-foot truss spans are very similar in construction. For uniformity they were all made 25 feet deep, centre to centre, of chords. Some details of the end of the 160-foot span are shown in Fig. 3. It is made up of six panels each of 26 feet 8 inches. The trusses rest on the caps of bents 9 and 10 and carry between them the floorbeams, which support the stringers on their top flanges. The end floorbeam as indicated in Fig. 3, carries one end of the forty-foot girder span and so is stronger than the intermediate floorbeams and lower than them by the amount that the forty-foot girders are deeper

than the stringers of the truss span. The truss spans have top and bottom laterals and at every panel point X bracing, the lateral wind force from the train and deck being resisted by the top lateral system and the resulting reaction at the ends of the truss being carried down through the end sway, bracing into the bents. Attention might be called to the bearings of the truss spans, the sliding bearing being shown in Fig. 3—a thick shoe plate on the bottom of the truss and two castings shaped to give a spherical bearing. At the sliding end two sheets of bronze are inserted between the shoe plate of the truss and the top casting, the sliding taking place between these two sheets. The truss is anchored to the bent with 2-inch bolts. This gives a simpler and more stable bearing than could be obtained by rollers—requiring less height.

The trestle posts were made of two 18-inch beams, two 20-inch beams, or two 24-inch beams, as indicated in Fig. 1—the details being shown in Figs. 2 and 3. These posts are stayed longitudinally and transversely at intervals not more than thirty-two feet

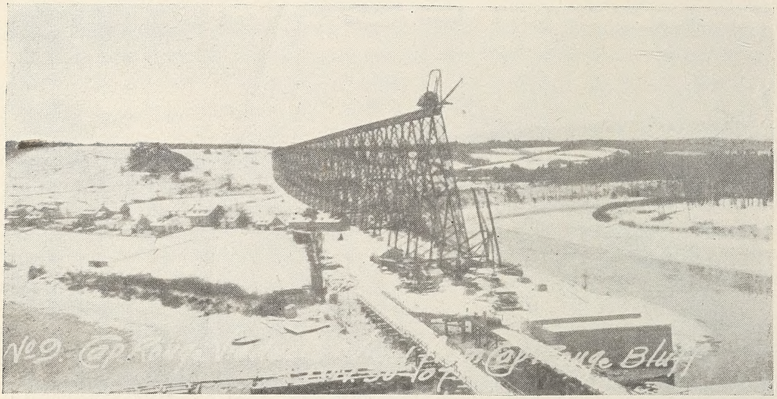


Fig. 5—From Bent 18 Westward.

apart by bracing composed of four angles latticed on four sides, as shown in Figs. 2 and 3. All trestle posts are given a batter of 1 in 6; the longitudinal bracing is therefore all in the same inclined plane, the distance, centre to centre, of trusses in the truss spans being made such that the posts of the supporting bents are in the same plane as those of the adjacent bents, carrying girder spans. The bents are anchored to the piers with anchors varying from 2 1-4 inches to 3 1-4 inches in diameter and from 7 feet 2 inches to 17 feet 7 inches long.

Erection was begun from the west end in July of 1907 and in the fall, when the work was stopped for the winter, they had got as far as bent 18. The trestle is being erected with a two-boom derrick, travelling on the deck and handling the girders and upper sections of posts and bracing. The lower sections are

handled by smaller derricks on the ground. It is proposed to erect the truss spans entirely with the derrick on the deck, using falsework. To facilitate this all splice plates on the chords of the trusses and all plates connecting to the web members are shop riveted to the chord sections on the west side of the splices.

Material was shipped from the works at Lachine entirely by scow, thus reducing cost of transportation to a minimum. As will be seen from the photograph, Fig. 5, Cap Rouge River takes a turn just on the north side of the trestle, running parallel to it for almost 1,000 feet, thus making it possible for a scow to be floated into the mouth of the river at high tide, across the line of the trestle, and upstream far enough to bring it about opposite bent 40, or about the centre of the length of the trestle. Here on the bank of the river a landing stage has been set up and all the material so far has been unloaded.

In conclusion, the writer desires to thank Mr. R. L. Uniacke, Bridge Engineer of the National Transcontinental Railway, for information and photographs kindly given, and the Dominion Bridge Company for access to drawings and other data in connection with the trestle.

FRENCH HYDRO-ELECTRIC POWER PLANTS IN THE VICINITY OF GRENOBLE

CHARLES H. MITCHELL, C.E.

M. Can. Soc. C.E.; M. Am. Soc. C.E.; A. Am. Inst. E.E.

As an especially notable example of the utmost development of mountain streams for power production, the writer has selected for presentation to the readers of "Applied Science" the region around Grenoble in Savoy. To realize the remarkable impetus given to manufacturers by the recent installations on these streams, one must actually visit for himself the several districts and note the completeness and various uses to which the electrical and mechanical power is put. The following descriptions were included in an illustrated address on the subject of European Power Development given by the writer before the Engineering Society of the University of Toronto not long since.* The illustrations shown were obtained by camera on personal visits to these plants during the year 1906.

The city of Grenoble lies in the heart of the French Alps. Its 70,000 people are engaged almost entirely in the manufacture of gloves and kindred leather industries, hats, buttons and clasps, linen and silk weaving, wood-working, paper, cement and miscellaneous iron manufactures. In earlier days, many of these industries were operated by small steam power units, and in the

---

*These plants, along with numerous others in Central Europe, are described more at length by the writer in a series of articles in the "Canadian Engineer," which appeared during the year 1906.

We are indebted to Mr. Mitchell for use of the plates illustrating this article.

case of paper and cement, by direct water-power, at the waterfalls in the vicinity of the city.

Since the advent of electrical transmission, however, the conditions have changed; now the numerous waterfalls are more advantageously developed and their power transmitted to the city and adjoining towns. Grenoble is situated at the junction of two small rivers, the Drac and its tributary the Isere, both rich in natural power. A few miles above the city, on the Drac, another tributary the Romanche enters, and this, notwithstanding its small size, is the most efficiently worked of the three. On these rivers and within thirty miles of Grenoble are now installed some sixteen hydro-electric and direct hydraulic plants, varying in capacity under normal conditions from 1,000 to 8,000 horsepower, and having an aggregate power of some 60,000 horsepower.

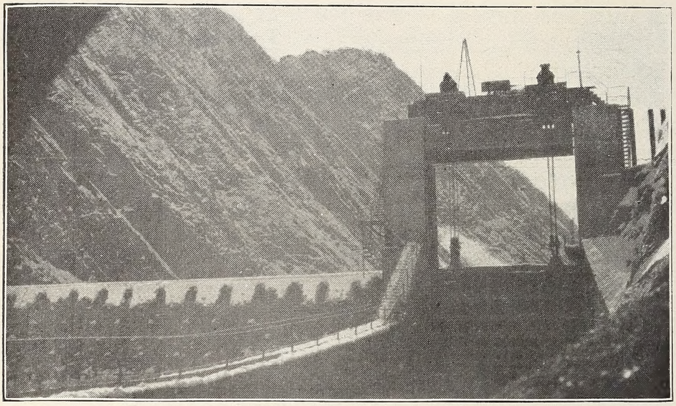


Fig. 1.—Avignonet Dam and Head Sluice.

Under these circumstances, it is not surprising that when a few years ago the French Government and the people took up the question of investigation of the water-powers and hydroelectric resources in the Alps, Grenoble was chosen as the headquarters and centre of operations of the Congress. The work of this body, known as the "Congress de la Houille Blanche," ("White Coal,") has now become world famous and its proceedings, bound in two large octavo volumes, form a most valuable engineering record, describing as they do in detail, the many plants then (1902) in operation and under construction.

The moving spirit of this congress was M. Berges, of Lancey, a small town in the valley of the Isere, about 10 miles north of Grenoble. He owned several mills utilizing water-power from mountain streams tributary to the Isere, aggregating about 6,000 horse-power; used mainly for pulp and paper manufacture, saw mills, etc., as well as lighting and traction purposes. That he is

a pioneer is evident from the fact that as early as 1868, he built the first conduit down the mountain and established a plant at Lancey, under a head of some 600 feet. A few years later, he increased this to 1,600 ft. head, using about 18 cubic ft. of water per second. This plant has continued in operation to the present time with but little trouble from the high head. A second installation here of about 2,000 ft. head remained until a few years ago the highest operated head in the world.

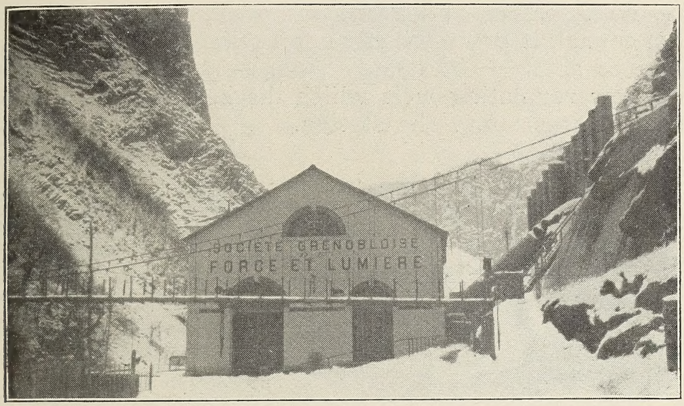


Fig. 2.—Avignonet Generating Station.

It is, of course, impossible in this article to adequately describe the many plants in the vicinity of Grenoble. Several of the more interesting installations are selected as typical of the district in which they are located.

AVIGNONET STATION, DRAC RIVER.

The Drac River drains a large area in the higher Alps and flows to the Rhone. Its dry weather flow in midwinter is fed only by springs, and above its junction with the Romanche does not exceed 800 cubic ft. per second. At times of freshet, however, this discharge runs up to the enormous flood of 40,000 cubic ft., a ratio of 1:50, which is most unusual.

The uppermost plant on this river at present is that of Avignonet, situated in a deep and narrow gorge about 25 miles above Grenoble. It is one of three plants owned by "La Societe Grenobloise de Force et Lumiere," and has an output under normal conditions of about 6,000 horse-power. The power is used in Grenoble for street railways and miscellaneous industries, for mines at La Mure, 8 miles away, and for factories at Bourgoin, 60 miles distant.

The general scheme of the plant is that of a dam in the gorge about 3,000 ft. above the station; a tunnel in rock, a forebay cut

in the rocky cliff; and penstocks to a generating station in the bed of the gorge; the hydraulic units operating under about 80 ft. head.

The dam is a heavy concrete structure of the over-fall type, with a total height of about 65 ft., having exposed faces lined with masonry. On one side is a sluice way closed by a Stony gate, about 25 ft. wide by 20 ft. deep. (See Fig. 1.) The dam is seldom over-topped by floods, the regulation being effected by the Stony gate. In front and shoreward of the sluice is the intake, with screens and headgates opening to head race, and being a tunnel, is protected from rock slides, and has a carrying capacity of about 1,400 cubic ft. per second. This tunnel has an overflow regulating weir which discharges into the river at about 200 yards above the station.

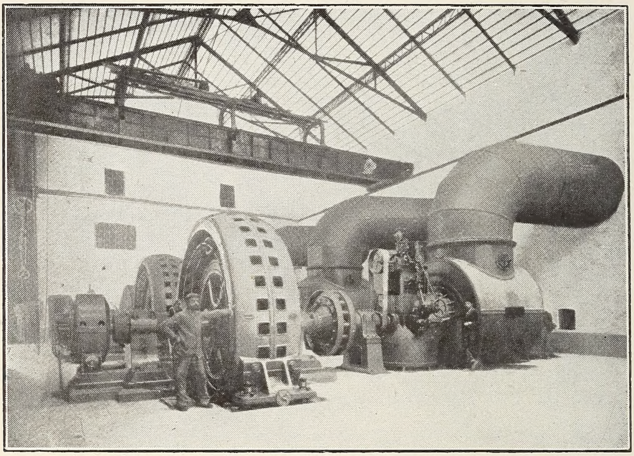


Fig. 3.—Interior of Avignonet Station.

The tunnel terminates in a forebay formed in the cliff by excavation and heavy masonry walls, provided with an adjustable weir and spill, and with separate screens and sluice gates to each penstock. The penstocks—five in number, with provision for two more—are 7 ft. diameter, and are fitted with 4 ft. diameter breathers below the sluice gates. See Fig. 2, in which may be also noticed a light suspension bridge crossing the river at this point.

The generating station is a heavy stone structure, equipped with five units, each of about 1,200 horse-power electrical output, with horizontal shaft, direct connected, at 250 R.P.M. The turbines are double "American" type, built by Piccard Pictet & Co., of Geneva, and are fitted with oil pressure governors, which appear to give good regulation. The generators are by Schneider

& Co., of Creusot, 3 phase—the latter being 15,000 volts. Three original units installed in 1901 were formerly wound to 26,000 volts, and intended to operate directly on the line without transformers; but these were found unsatisfactory, hence were rebuilt for 15,000 volts. The transformers are 15,000 to 26,000 volts, air cooled. The interior of the station is shown in Fig. 3.

The transmission line is interesting from the fact that the portion nearer to Grenoble is used jointly by this and another company (Champ Station, described below). The line from Avignonet to Grenoble consists of three circuits carried on iron poles. The towers for the joint transmission line shown on the right hand of Fig. 4, are about 40 ft. high above ground, and carry six circuits of 26,000 volts. These towers are set 6 ft. in the ground in concrete, the cross arms are wood, 10 ft. long, set in an iron framework, and each tower costs, complete, $100. At the junction with the second company, about 8 miles above Grenoble, a special structure (Fig. 4) is erected, and similar ones are also used in the city. Each company has its respective side and interconnecting and sectional switches. The two companies work in harmony, one using the other's wires at times for repair on the other side of the tower.

The snow seen in the accompanying pictures, while common, is unusual to such an extent in this locality. There is no trouble from floating or frazil ice, however, in any of the power plants in the vicinity of Grenoble.

CHAMP INSTALLATION, DRAC RIVER.

The Champ Station is situated near a village of the same name, and is about 8 miles above Grenoble, at the junction of the Romanche River. It is owned and operated by the Fure & Morge Co., of Grenoble, and under normal conditions of river has an output of about 6,000 horse-power, which is used for miscellaneous factory power in and near Grenoble. There are upwards of 70 works now connected through about 15 receiving stations. It was first operated in 1902.

The general scheme is quite different from the plant at Avignonet, owing to the nature of the river at this point, which is shallow and flows through a gravel bottom in a wide valley. The intake works are situated about 3 miles up stream and the water is conveyed to the generating station by means of a flume laid underground; the station stands in the flat bed of the valley and the water is discharged through a short canal into the river channel near by.

The intake consists of a submerged dam at right angles to the stream, terminating near the shore, in an intake set parallel to the stream, consisting of submerged arches provided with gratings and sluices. Special precautions were required in this respect to prevent entrance of debris, gravel and stones, of which the river carries considerable. Behind the intake is a headbay

1,900 feet long, acting as a settling basin and provided with overflows having adjustable crests. At the end is a bell-mouthed entrance to the flume, fitted with a gate having an air inlet behind.

Fig. 4.—Junction Tower, Transmission Line.

This flume is a most interesting work, about 14,000 ft. long, 10 ft. 8 in. interior diameter, laid on a grade to conform to the slope of the river, partly in trench cut, and then filled over with gravel and earth. Its carrying capacity is figured at about 800 cubic ft. per second at a speed of 10 ft. per second. The upper 6,000

ft. being under light pressure, is of concrete reinforced with steel rods. The girth rods, a few inches apart, vary from ½ to 1 in. diameter, and the longitudinal ones from ¼ to ½ in. The whole thickness of shell varies from about ⅞ to 1¼ in. The remainder

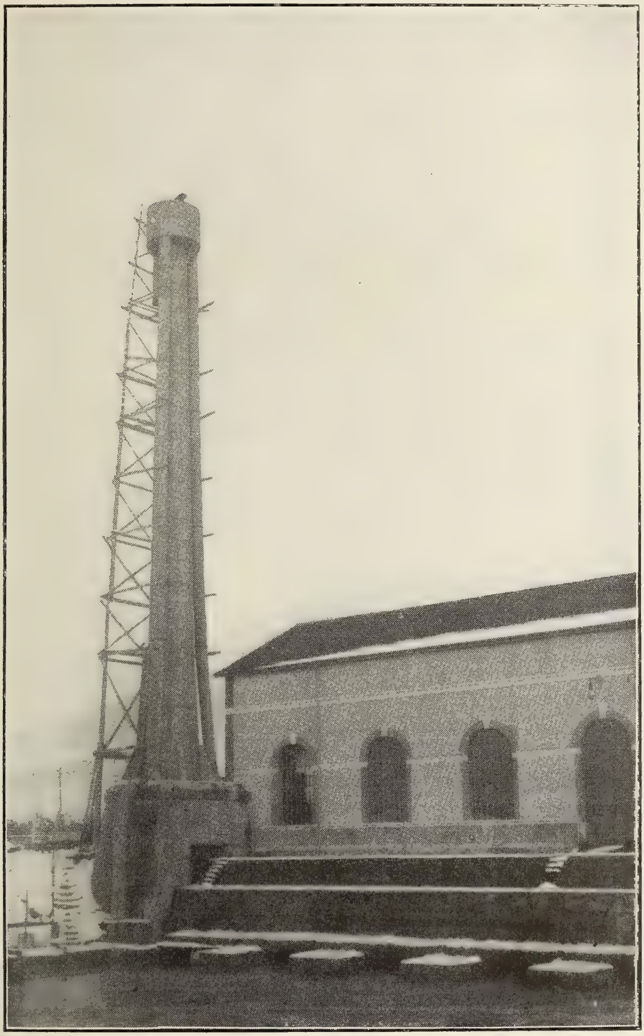


Fig. 5.—Terminal Overflow Pipe, Champ Station.

of the flume is of steel plate from ⅜ to ⅝ in. thick, and the structure throughout rests on a concrete foundation about 12 in. thick. There are three air shafts or breathers carried above the head level about 4 ft. diameter, along the length, to provide

against entrained air or collapse when emptying. The most interesting feature of this flume is the terminal air shaft at the generating station, which consists of a vertical prolongation of the steel flume after the penstocks are taken off leading to the turbines. The vertical shaft converges from the 10 ft. diameter to about 5 ft. at the top, a total height above tail water of about 140 ft. The top terminates in an open chamber drained by three down pipes 18 in. diameter leading to outlets in the tail race. The water stands up to about 116 ft. above tail level when the plant is not operating, but when running full load this becomes 100 ft., which is the working head, the difference being friction and entry losses.

Referring to Fig. 5, showing the stand pipe relief, a scaffold for repairs will be seen. It may be interesting to note that about three weeks before the writer's visit on February 13th, 1906, the upper part of the pipe collapsed from a singular cause. A few days of cold weather caused ice to form near the top with the water at a high level. Subsequently, when the water lowered suddenly, a vacuum was formed resulting in the crushing of the thin steel shell for about 20 ft. from the top. While this accident might happen in Canada, it is considered as a very unusual occurrence here.

The turbines, five in number, are supplied by short horizontal penstocks connecting with the main flume, fitted with butterfly valves. They were built by Neyret-Brenier & Co., Grenoble, and are single wheels on horizontal shafts with cylinder gates, operating at 300 R.P.M. giving 1,500 horse-power. Though several wheels are fitted with simple governors they are regulated by hand, and appear to be fairly steady. In addition to the stand pipe relief, there are automatic relief valves on each turbine, which are also fitted with hydraulic servo-motors operating the distributors and compensating valves, thus shunting the turbines and maintaining a nearly constant flow in the main flume. The attendants say that the normal variation in level in the standpipe when operating is about 6 inches.

The generators are by Brown Boveri & Co., of Baden, 1,000 k.w. revolving field 3,000 volts, direct connected, and with the switchboard and transformers from 3,000 to 26,000 volts, present no especial features. The transmission lines are described above.

GAVET STATION, ROMANCHE RIVER.

The Romanche River has distinctive features which are remarkable. Its flow is very small, in dry weather being only about 300 cubic ft.; normal for about 9 months about 700 cubic ft., and flood discharge about 6,000 to 9,000 cubic ft. per second. Its descent is very rapid, hence high heads are the rule in the seven plants situated within the 12 miles of its course. These plants aggregate nearly 40,000 horse-power, and are used for various purposes; mainly in electro-chemical industry. There

are several carbide of calcium works, and at Livet, 24 miles from Grenoble, is the celebrated electric steel works of Keller Leleux & Co. At Livet is located also the municipal plant, generating light and power current for Grenoble. The transmission line of the latter is unique, for it is constructed with wood-concrete poles, that is, thin straight cedar poles encased in an envelope of concrete from 1 to 2 in. thick, which in the three years of operation appear to have given entire satisfaction. A careful examination of these revealed no serious cracks and it has occurred to the writer they might be tried with success in Canada, notwithstanding the cold weather conditions.

The Gavet Station, just completed, is situated about 8 miles above the Champ Station, or 16 miles from Grenoble. It also is owned by the Societe Grenobloise de Force et Lumiere, and commenced operations about March 1st, 1906. There are now three units installed, with a total output of about 5,000 horse-power, and provision for doubling this capacity. The low water

Fig. 6.—Interior Gavet Station.

period of the river, however (about three months) gives only about this amount. The power will be used for manufacturing, both mechanical and chemical.

The headworks are very ingenious, and a type of all plants on this river, which floods quickly and carries large quantities of gravel, etc. The head dam consists of piers and buttresses carrying two steel Stony gates (counter-balanced), each about 30 ft. wide and 12 ft. deep, capable of being operated by hand by one man. In front of the dam is a weir parallel to the stream, with its crest about 2 ft. below the top of the gates; behind this is a settling basin having a sluice at the lower end and having a second similar weir on its opposite side. Water, after passing the first two weirs, enters a second elongated basin, having, at the lower end, a third sluice, and, in the side, the head screens

leading to the head race, which is provided with a simple gate about 12 ft. wide, 10 ft. deep. This scheme offers two Stony and two secondary sluices for normal flood water and permits the passage of abnormal floods over the whole; at the same time it provides settling or catchment basins for gravel. The flume to the generating station consists of a tunnel driven in the rock cliff about 10 ft. square and 7,000 ft. long.

The tunnel terminates in a small covered forebay high up the face of the cliff above the station, having outlets for two penstocks and one spillway. The penstocks—one of which is now installed—follow down the cliff, and are 7 ft. diameter by about 500 ft. long, and each branches to the three main and two exciter units at the rear wall of the station.

The station is of rubble stone, having a generating room, commodious switch-board gallery, wire ducts, transformer and arrester rooms. The writer had the pleasure of visiting the plant

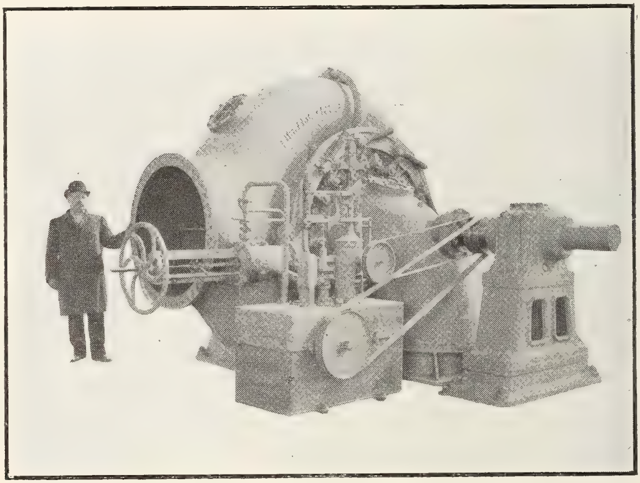


Fig. 7.—Gavet; 2,000-H.P. Turbine.

on February 14th with the consulting engineer, M. Boissonas, of Geneva, who pointed out many of the new features. On this occasion the units were started on their first long run, for the purpose of drying out the generators and transformers.

Each turbine develops 2,000 horse-power working under a head of 190 ft., and they are of the horizontal shaft, single spiral Francis type, built by Piccard Pictet & Co., of Geneva. The distributor gates are swivel style, with an actuating gate ring carried on arms fitted with springs, to positively take up lost motion. The governors are by the same makers, arranged with a new device on the fly balls, to stop petty vibrations. The main shafts have fly wheels (see Fig. 6) and Zodel flexible leather link couplings.

The generators are by Schneider & Co., Champagne, revolving field type, three phase, 4,000 volts, 231 amp. per phase. The transformers step up to 26,000 line voltage the same as at Avignonet, with which this station will at times be run in parallel, 24 miles distant. The line is at present carried on wooden poles.

POWER PRICES IN GRENOBLE.

Good quality steam coal in Grenoble costs about $5 per ton. The two power companies in the field sell for about the same prices. Those of the Societe Grenobloise are, in general, as follows:— For 24 hours service the average prices (variable on account of distance) are, say for 100 horse-power, $30 per horse-power year, and for 500 horse-power about $26 per horse-power year. In 500 horse-power quantities prices run down as low as $18 for transmitted power and even to $12 at the station. This company has now 15-year contracts for about 15,000 horse-power, with some customers 100 miles distant (by line). In the case of the Champ Company selling upwards of 4,000 horse-power, the average price per horse-power of the output is about $25 on a 12-hour day and $30 on a 24-hour day. Lighting current, sold in Grenoble by the city plant, costs about 12 cents per k.w hour.

THE MAPLE CREEK WATER SYSTEM

GEORGE T. CLARKE, '06.

GENERAL CONDITIONS.

The conveniences of a public water supply for villages, towns and cities are too well known to need any argument in their favor. There are four chief conditions which such supplies should fulfill in order to adequately meet the requirements of the community in whose behalf they are constructed and operated. First, the water supply should be wholesome and adapted to all domestic uses. Second, the supply should be abundant. Third, it should be delivered under a sufficient pressure. Fourth, it should be furnished at a cheap rate to the consumer.

Regarding the first named requisite without entering into conclusive statistics, which prove the statement, it will suffice to assert that the introduction of a wholesome public supply of water has invariably exercised a beneficial effect upon the death rate and general health of the community using it. Particularly is this the case regarding diseases of the typhoid and typho-malarial classes and it must be observed that in studying the sanitary conditions of any community not only the death rate, but the general health enjoyed by such community should be taken into consideration. Generally the one is an index of the other.

Regarding the abundance of the supply, water is needed for many purposes in towns and cities, both public and private. Public services comprise a fire supply, street sprinkling, the

flushing of sewers, public fountains, etc. Private services comprise the water needed for drinking, cooking, washing, bathing, lawn sprinkling, etc.

In the early days of the general introduction of water supplies it was customary to itemize all these various services, alloting so many gallons for each and taking the sum total. At present, with all the experience of the past to guide us, it is found that they may all be combined in a general per capita allowance and in making the count of the number of inhabitants to be supplied, it is necessary to forecast the probable growth of the town, providing for the prospective needs of the community for the next twenty-five years at least.

The third consideration and a very important one is that of pressure. Most towns cover a territory more or less varied as to elevation. A great difference in level in the different parts of a town makes the problem somewhat complicated, because the pressure sufficient to carry water to the most elevated district will be embarrassingly great in the lower ones and consequently it is frequently necessary to reduce the pressure in the house connections in the latter case.

On the other hand it is frequently necessary to have a separate high pressure system to reach the more elevated portions of the town. This is generally accomplished by pumping into a small distributing reservoir. This necessitates an independent system of mains.

The great advantage of a high pressure at the hydrants is in connection with the fire service. Frequently if the pressure is high, streams may be got upon a fire by merely connecting the hose with the hydrants.

The water rate naturally must be sufficiently large to at least cover the expenses of the water supply, these expenses consisting of interest on the cost of the work, depreciation of the plant, and expenses of the operation and maintainance. Therefore the works should be built and operated with the greatest economy and from the start all unnecessary loss from waste and leakage should be reduced to a minimum.

SOURCES OF SUPPLY.

All the water supply of the earth is derived primarily from the water which falls on its surface. This deposit disappears in four different ways, evaporation, absorption by plant life, by running off as surface water and by percolation through the ground. The latter is termed ground water and of this class the purest and most desirable for public water supply is that obtained from springs.

The comparatively close proximity of never failing springs with an abundant supply, combined with other advantageous conditions made it possible for the town of Maple Creek, Saskatchewan, to install a public water system at a moderate

cost. The Cypress Hills, a few miles to the south, form a very large water shed. Owing to the altitude of these hills the deposit of moisture is considerably in excess of that on the surrounding prairie and at the same time the evaporation is much less, owing to the hills being heavily wooded. Consequently there is a proportionately large amount of ground water, percolating through the soil until it strikes some seam of gravel or other loose formation, reappears in the foothills at many different points in the form of springs.

The series of springs selected by the town's consulting engineers is distant approximately eight miles from the corporation limits. These springs have an output of five hundred thousand gallons per twenty-four hours, and this flow has remained practically constant for the past twenty-five years at least.

The spring is located at the head of a small valley and the proposition was considered of building a dam across this valley, thereby forming a natural reservoir. However, under local prevailing conditions in that locality spring waters when stored in open reservoirs undergo changes which greatly impair their quality. The bright light and long hours of sunshine are particularly favorable to the growth of Algae and other vegetable organisms. These growths give the water a bad odor and taste, particularly in the summer season. Owing to these conditions it was decided to accept the other alternative and substitute for the dam a covered, reinforced concrete, compensating and storage basin. This alternative did not provide for storing as large an amount of water. But as the total supply was much in excess of the demand, an efficient service was given by the smaller reservoir, besides the great advantage of keeping the water clean and palatable at all seasons. This, in the opinion of the engineers, outweighed the advantage of larger storage.

The second advantage was gained by the compensating nature of the smaller basin, for by placing it nearer the town the pressure on the distributing system was diminished and at the same time the delivery was increased.

The springs themselves were carefully developed, so as to obtain the maximum flow. Then mains of vitrified pipe collect the water and conduct it to a small intake chamber. The system then consists of:—

1 The collecting mains.

2 The intake chamber.

3 A 10-inch wood main from the intake chamber to the storage basin.

4 The storage basin.

5 A 12-inch wood main from the storage basin to the distribution system.

6 The wood distribution system, including valves, hydrants and all appurtenances.

The difference in elevation between the intake chamber and

the compensating reservoir is 37 feet, and the distance between them is 4,000 feet. Hence the 10-inch pipe is sufficiently large to conduct all the water from the springs to the reservoir.

The reservoir itself, which will hold two hundred thousand U.S. gallons, is provided with overflows, which conduct the excess water back into the creek. The difference in elevation between the town and the reservoir is 230 feet, making the static pressure on the distribution system practically 100 pounds. The town site is very even in elevation and consequently this pressure is practically constant over the whole system, and while it is a little high for domestic uses, yet it affords an excellent fire protection, and as we have previously stated this is a very important consideration in the installation of a public water supply.

Hence we see that in three respects, at least, the Maple Creek system conforms with the required conditions, namely:—

1 The supply is wholesome, as shown by the analysis of the water.

2 The supply is more than abundant for a town of 1,000 population.

3 It is delivered under a pressure not too great for domestic use, but great enough for fire protection.

On account of the fact that wood pipe is comparatively little used in Eastern Canada, it would probably not be inopportune to give a short description of it. Wood pipe is made from the best quality of kiln-dried Douglas fir, or Canadian white pine, free from knots, shakes and other imperfections. It is constructed of staves approximately an inch thick and two and a half inches wide, each stave being part of the circumference of a circle. The staves are made with tongues and grooves and after being placed in position are wrapped spirally under tension with drawn steel wire, or flat steel bands, the size of this wire or band and the spacing of it depending entirely on the pressure which the pipe has to stand. It is then dipped in a boiled asphalture compound at 300 degrees F., the object of this being to protect the wire against being destroyed by the chemicals in the earth.

The joints are made by simply driving the pipes together with a maul or ram. The efficiency of this wood pipe joint as it is at present manufactured seems to depend entirely on whether or not the wood, when water-soaked, will swell sufficiently to completely fill up the spaces between the spigot end and the coupling. Practically all the leaks in wood pipe are at the joint and when due care is not taken, and sometimes in spite of the best of care these leaks are frequent. This is a very great disadvantage to wood pipe. Another disadvantage in wood pipe is that it is not as adaptable for use in distribution systems, because the necessity for tapping these mains for house connec-

tion exposes the banding or wrapping to possible damage, both to coating and metal and thus deterioration begins.

There are three advantages claimed by some on behalf of wood pipe over cast-iron pipe.

These are:—1st The initial cost is decidedly less .

2nd There is no possiblity of destruction by electrolysis.

3rd The interior of the pipe does not suffer deterioration with age, if anything the friction factor decreases.

The third advantage named above affects directly the carrying capacities of the pipes. This carrying capacity has been determined with more or less accuracy by experiments made by many scientific investigators and covering many actual and supposed conditions. In reducing these experiments to a formula for ready use a value has been given to the roughness of the wetted surface of the conduit, the rougher the wetted surface, the less the capacity of the pipe. The value of "*F*," (representing the roughness) has been found to vary from 0.0115 for new cast-iron pipe, to 0.020 for tuberculated pipe; from 0.0115 for new steel riveted pipe to 0.017 for steel pipe in use for 14 years and from 0.011 for new wood stave pipe to 0.0096 for wood stave pipe in use for 10 years.

In every recorded experiment made to ascertain the carrying capacity of iron and steel which has been in use for a number of years, it was ascertained that the value of "*F*" had largely increased, whereas experiments upon old wood stave pipe have shown the reverse. The cause of the diminished capacity of the iron and steel is the gradual formation of nodules of rust or tubercles and the accretion of various organic growths on the inner surface of the metal. On the other hand, where a wood pipe has been kept full of running water, its inner surface becomes smoother with use.

Mr. Arthur L. Adams, a leading hydraulic engineer of the Pacific Coast, in a paper presented to the American Society of Civil Engineers, says:—"Clean cast-iron pipe would seem to have about 90 per cent. of the carrying capacity of a wood stave pipe, while, if seriously tuberculated, they discharge only about 66 per cent. as much as wood stave pipe of the same size. Clean steel pipe discharges 93 per cent. as much as wood stave pipe, while if tuberculated to an extent, which may easily occur in ten to fifteen years' use, these discharges may fall to 74 per cent. as much as wood stave pipe."

Omitting other considerations, is not the value of a pipe line investment porportional to its delivering capacity? Do not these percentages, then, represent approximately the relative value of these different classes of pipe as an investment.

The following table is submitted, based on six per cent. interest compounded annually on the difference between the cost of furnishing and laying cast-iron and wood stave pipe, exclusive of trenching. Prices stated are approximate only:—

Size	Wood	Cast Iron	Difference in Cost	Interest on difference in cost will re-build wood in
12-inch	$0 82	$1 64	$0 82	11.4 years
24-inch	1 65	4 61	2 96	7.6 years
36-inch	2 72	8 88	6 16	6.3 years
48-inch	4 25	14 00	9 75	6.2 years

Regarding the durability of wood pipe, under the usual conditions, it is conceded by those familiar with the subject that the life of wood stave pipe depends on two things. First, the necessity of keeping the pipe under such pressure as will thoroughly saturate the wooden shell. Second, the life of the iron or steel bands surrounding the staves.

Some examples of the durability of wood pipe as at present manufactured are here given. In 1862 the City of Victoria laid a distribution system of wood stave pipe, which was in constant and successful use until 1901, when they were removed to give way to pipes of larger capacity. In 1856 Elmira, N. Y., laid wood stave pipe, several miles of which are still in use under pressure ranging from 35 to 70 pounds. The water supply mains for Denver, Col., consist of over 100 miles of wood stave pipe, many miles of which have been in continuous use under high pressure for over 20 years without apparent diminution in service.

There have, no doubt, been failures in wood stave pipe, as there have been also in cast-iron and steel pipe, due to an unfamiliarity with the principles involved in their uses and it is for the competent hydraulic engineer, who is familiar with all three classes of pipe to determine that which should be used in each case.

ESTIMATED COST PRICES

I. Supply Main:

Material	Total Cost		Average Cost Per Lin. Foot	
Wood Pipe	$23,365 27		0.59½	
Valves and Specials	999 48		0.02½	
Labor				
Trenching	11,592 02		0.29½	
Pipe Laying	1,375 32		0 03½	
Tamping and Backfilling	1,178 85		0.03	
	———	$38,710 94	———	0.98

II. Distribution System :

MATERIAL			
Pipe....	$6,879 18		$0.42
Special Valves and Hydrants ..	3,767 17		0.23
LABOR			
Trenching	4,094 75		0.25
Delivering Pipe	245 68		0.015
Laying Pipe and setting Valves and Hydrants	1,556 00		0.095
Tamping, Backfilling and Trimming Trench	1,064 63		0.065
	———	17,607 41	———$1.075
Building Intake and Developing Springs		1,081 65	
Building Reservoir		3,600 00	
Total cost		$61,000 00	

Average cost of labor 27½ cents per hour.

RAILROAD CONSTRUCTION

F. H CHESNUT, '08.

Gentlemen:—The subject which we are to consider is that of railroad construction. It is the object of this paper to bring before you in a concise manner what is required of an engineer on construction work.

If a line of railroad is to be constructed, say 100 to 300 miles long, the whole line is placed in charge of one man—the chief engineer. The line may then be divided into 15-mile to 50-mile divisions; each division being under the charge of a divisional engineer. These divisions are again subdivided into sections, which are under the supervision of resident engineers. Most companies also have bridge engineers each having charge of three or four bridges. It is, however, the duties of a resident engineer with which we are concerned.

We may conveniently divide his duties under two main heads:

(a) The laying out of the work and the office work resulting therefrom.

(b) The supervision of the work of construction.

Considering the first division:

When a resident engineer takes charge he is given a graded profile and plan (or notes of the same) of his section. The centre line is usually laid down on the ground, being marked out by stout stakes. As it sometimes happens the location has been made in the winter and for this and other reasons a number of the stakes may be pulled out or misplaced. Unless the engineer is absolutely sure that the centre line is correct, that is that all stakes are in place or that all tangents are straight or that all

curves have been properly run, he should rerun the line, correcting all small errors in chainage and carry all equations in chainage through to the end of the section.

When the centre line has been properly fixed it is then required to spiral the curves which require easement. Some roads instruct their engineers to spiral all curves over 1° 30'; others require 3° curves and over to be spiraled.

Among the several forms of spiral is that used by C. N. R. resident engineers. It has proved very satisfactory and its simplicity makes it capable of being handled by even the novice. The following remarks on this spiral contain practically no theory, but simply the facts required to lay such a spiral down on the ground.

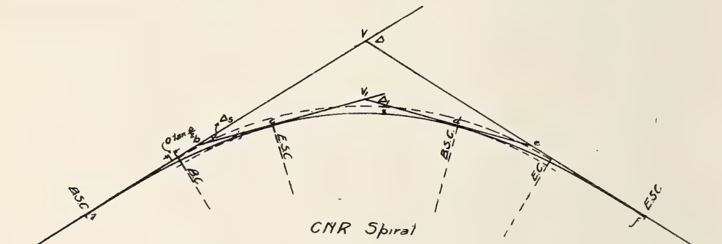


Fig 1

The C. N. R. spiral assumes (in most cases) chords of 30′ in length, and one chord to be used per degree of central curve. That is to spiral a 4° curve we use 4 chords of 30′ or 120′ of spiral. To show the practical working of this curve we may examine the following example.

Suppose that we have a 5° curve with an intersection angle of 50°. We wish to spiral this curve using 30′ chords.

Then 30′ × 5 = 150′ is length of the spiral.

At the *B S C* (Fig. 1) the curvature of the spiral is zero; at the end of the first chord it is 1°; at the end of the second chord it is 2°; and so forth until at the end of the 5th chord the curvature is 5° or the same as the simple curve. The curve has then an average of 2° 30′. Now a 2° 30′ curve running 150′ would consume 3° 45′ in a central angle. Therefore 3° 45′ is the central angle ($V\ b\ c$) of the spiral. The two spirals (one on each end of the curve) consume in all 1° 30′ and this subtracted from the central angle of the main curve gives 42° 30′ for the central angle ($\triangle$) of the new 5° curve.

Then to find the *B S C.* The subtangent for the spiraled curve consists of three parts, viz., ½ the spiral = 75′; the subtangent for a 5° curve with an angle of 50° = 534.′3; and a variable quantity $O \tan \frac{1}{2} \triangle$, which varies with the central angle and the degree of the curve. A table of values of $O \tan \frac{1}{2} \triangle$

is given for curves up to 6° and angles up to 90°. By interpolation intermediate values may be found.

$$\text{Then } T_s = T + \tfrac{1}{2} S + O \tan \tfrac{1}{2} \Delta$$
$$= 534.'3 + 75.'0 + .381 = 609.6$$

Then we measured back from V 609.′6 or back from the $B\ C$ 75.′3 and we are ready to run the spiral.

By reduction from theoretical formulae it is found that the deflection angles are as three times the square of the number

	Values of O tan ½ Δ for 30′ Chords						
	Δ° = 30°	Δ = 40°	Δ = 50°	Δ = 60°	Δ = 70°	Δ = 80°	Δ = 90°
2° c	014	019	.024	.030	.037	.044	.052
3° c	.047	.064	.082	.102	.124	.148	.177
4° c	112	152	195	.242	.293	351	.419
5° c	219	.298	381	.472	373	.686	.818
6° c	.379	515	659	.816	.990	186	1.414

FC

Fig 2

of chord lengths from the $B\ S\ C$. The right hand portion of the above table gives the deflection angles to be used for curves from 1° to 10°. For this curve we use for the 1st chord 3′; for the 2nd, 12′, and so forth and for the 5th, 1° 15′, turned off from the tangent $a\ b$. This last deflection fixes the $E\ S\ C$ which then is 150′ from the $B\ S\ C$ (measured along the curve). It is seen

Deflections For Last Spiral											
No of Chord	Length of Spiral	Deflection angles for Curves From 2° to 10°									Def. ∠'s for 1st Spiral
		2°	3°	4°	5°	6°	7°	8°	9°	10°	
1	30	15′	24′	33′	42′	51′	1° 0′	1° 09′	1° 18′	1° 27′	3′
2	60	24′	42′	1° 0′	1° 18′	1° 36′	1° 54′	2° 12′	2° 30′	2° 48′	12′
3	90		54′	1° 21′	1° 48′	2° 15′	2° 42′	3° 09′	3° 39′	4° 03′	27′
4	120			1° 36′	2° 12′	2° 48′	3° 24′	4° 0′	4° 36′	5° 12′	48′
5	150				2° 30′	3° 15′	4° 0′	4° 45′	5° 30′	6° 15′	1° 15′
6	180					3° 36′	4° 30′	5° 24′	6° 18′	7° 12′	1° 48′
7	210						4° 54′	5° 57′	7° 0′	8° 03′	2° 27′
8	240							6° 24′	7° 36′	8° 48′	3° 12′
9	270								8° 06′	9° 27′	4° 03′
10	300									10° 0′	5° 0′

FC

Fig 3

from Fig. 1 that angle $v\ b\ c$ = angle $b\ a\ c$ + angle $b\ c\ a$. But angle $v\ b\ c$ = 3° 45′ and angle $b\ a\ c$ = 1° 15′. Therefore 3° 45′ — 1° 15′ = 2° 30′ which is twice angle $b\ a\ c$. Then setting up

at c and sighting a we turn on to the tangent to the spiral (also the tangent to the central curve at this point) by turning through twice the angle we used to fix the point c. We are then prepared to run our central curve which is a 5° curve for 42° 30′ (or 805′ of curve); which brings us to d. If the circular curve were run past this point we would find that the spiral leaves this curve (on the outside) at the same rate as it left the tangent in the former case. Then to obtain the deflection angles from the *B S C* for the spiral we proceed thus: In 30 feet the circular curve would have turned from its tangent $\frac{30}{100} \times 2° \ 30'$ (def. angle for 5° curve) $= 45'$. But the spiral turns from the main curve towards the tangent in 30′ an angle of 3′. Then taking the difference we find that the spiral leaves the tangent de 42′ for the first chord. In the same way for the second chord the curve turns in 60′ through $\frac{60}{100} \times 2° \ 30' = 1° \ 30'$; but the spiral leaves the curve 12′ for 60 ft. $\therefore$ the spiral leaves the tangent 1° 18′ for the second chord. The left hand portion of the above table gives the deflection angles for curves from 2° to 10°. Turning off 2° 30′ we set a hub 150′ away (measured on the curve) and this is the end of the spiral and should come on the main tangent if the curve has been carefully calculated and run properly. If trouble is found in fitting the curve in, it may be run from both ends and flattened slightly in the middle; but such a course should not be followed except as a last resort. This form of spiral may also be applied to existing track; but in this case while the middle point of the central curve remains unchanged the curve is sharpened.

When all curves which require it have been spiraled we then have the centre line fixed absolutely. It now remains to permanently fix it, that is, to reference a number of the main hubs out to the sides of the line. Many good methods will suggest themselves to the engineer. It may be well, however, to note that heavy hubs (6 in. in diam. where possible) and large guard stakes (3 ft. long) should be used to insure against uprooting by frost, etc.

We have now the centre line permanently and accurately fixed, and are in a position to commence cross-section work. This should be commenced at one end of the section, when possible, and carried right through to the other, thereby keeping the notes in good shape. Before cross-sectioning is actually started, check levels should be run over all bench marks, small errors corrected and bench marks placed at convenient points, such as large cuts or where trestling is proposed. Cross-sectioning is then carried on by the ordinary method which is so well known as to require no explanation. It may be said, however, that slope stakes should be placed at every station of 100′ and grade plugs where the centre line and the two edges of the roadbed come to grade. Sections should be taken at these grade points if accurate volumes are expected. This should be carefully noted as it is

a frequent source of error. In cross-sectioning due allowance should be made for vertical curves at the meeting of two steep grades. Simple methods of running these curves will be found in most engineers' hand-books.

If bridging or trestling is proposed it is the duty of the resident to take careful cross-sections of ravines or river crossings, plotting his results on cross-section paper using scales of $10' = 1''$ horiz. and vert. Soundings should also be taken in swamps or muskegs which have the appearance of being too soft to hold a dump. These soundings can be conveniently taken by joining several lengths of gas pipe together, the end one being hammered to a point. You will base your judgment as to whether a dump or trestle will be required, on the resistance the ground offers to the rod and the distance to which you can sink it. It must be remembered, however, that trestles are only temporary and will be replaced by embankments when they begin to show signs of failure. For this reason embankments are preferable even if cross-logging has to be resorted to in order to keep the dump from sinking.

Proceeding to the office work, we will find that the first thing which presents itself is the working out of the cross-section notes or in other words the finding of the volume of material in cuts and fills between their respective grade points. This is usually done by the well-known method of end areas and is accurate enough for almost the most exacting. An office cross-section book should be kept with its pages ruled as follows:

Sta.	Area	M. Area	Dist.	Cu. Ft.	Cu. Yds.

Fig. 4

It is not necessary to fill out the column for cubic yards between each cross-section station except in cuts and fills where overhaul is to be calculated.

In the office also should be kept a book of general information. Starting at one end of the section, this book should contain all information with regard to yardage in cuts and fills, lengths of pipe in drains, culverts and farm crossings, yardage in farm crossings and public road crossings, yardage in borrow pits and side ditches, farm gates and all other information available. Everything set down should be in order of stations and put in such a lucid manner that any one glancing over the book could formulate an idea of the work being carried on.

Most companies require the engineer to keep what is known as the Force Account or the number of men and teams which the contractor has working each day. This should be returned to the divisional engineer every week or so. The object of this

Force Account is to obtain data from which can be calculated the exact cost of building a line. Knowing the force the contractor has on and the cost of labor, teams and material, we can arrive at a very close estimate of actual cost. From these figures it is possible for a railway company to judge closely what other work will cost, taking into account differences of prevailing conditions.

When material is hauled over a certain distance (freehaul usually 500′) it is known as overhauled material and is paid for at so much a cubic yard for each hundred feet hauled over the freehaul distance (usually one cent). The best method in use for finding this yards overhaul is the graphical method here illustrated.

Station	Cubic Yards	Sum of Cubic Yards
1	1516	10081
2	1516	8565
3	1422	7049
4	1331	5627
5	1243	4296
6	1027	3053
7	770	2026
8	571	1256
9	453	685
10	205	232
11	27	27
+20	47	
12	296	47
13	701	343
14	994	1044
15	1157	2038
16	1331	3195
17	1516	4526
18	1613	6042
19	1613	7655
20	1613	9268
21		10881

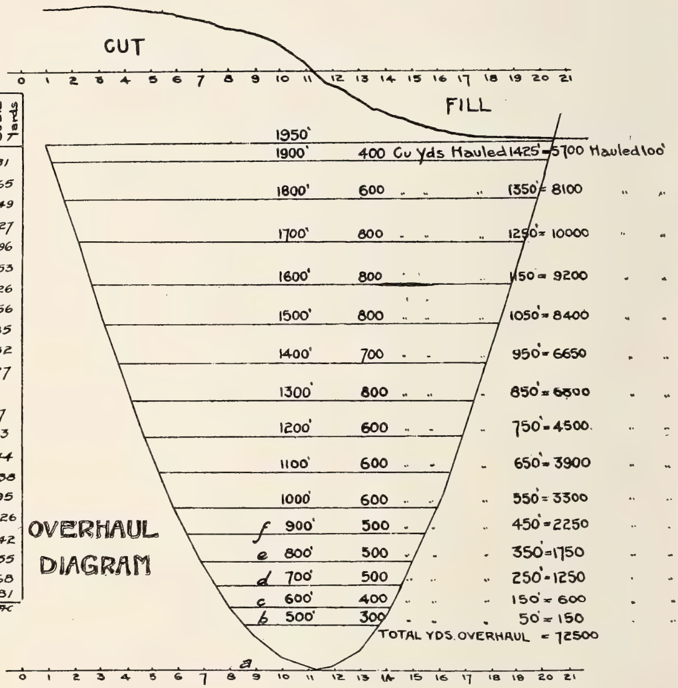


Fig 5

From the book containing the volumes calculated from the cross-section notes, we may formulate a table as shown. The second column contains cubic yards between cross-section stations and the third column these cubic yards summed to each cross-section station on each side of the grade point. Then on the same paper on which our profile of the centre line is plotted we may plot the overhaul curve, using any convenient vertical scale of cubic yards per inch and the usual horizontal scale of $400' = 1''$. Thus the ordinate to the curve at station 7 represents to scale the quantity of material between station 7 and the grade

point, as also the ordinate to the curve at station 15 represents the quantity of material between station 15 and the grade point. When the curve has been plotted back as far as the cut has been excavated (say station 1), and in the fill far enough to balance this, we take a 40 scale and sliding it up the curve, keeping it horizontal, we find the height at which 500 scaled feet will just fit between the curves; drawing a horizontal line we proceed until 600 scaled feet just fit between the curves. Thus to the top of the curve. We have now found different points in the cut where material is hauled distances differing by 100 feet. It is readily seen that the amount of material removed before we begin to haul 500 feet is represented by the vertical ordinate to the first horizontal line and is called the freehaul. This can be found by scaling. In the same way b c represents the number of cubic yards of material removed between the hauls of 500 and 600 feet, and c d, d e and e f each represent the cubic yards of material removed between their respective limits. It is seen that the 300 cubic yards of material between b and c have been overhauled from zero to 100 feet, or an average of 50 feet. 300 cubic yards hauled 50 feet = 150 cubic yards hauled 100 feet. In the same way we have 400 cubic yards hauled 150 feet = 600 cubic yards hauled 100 feet. Adding up the cubic yards overhaul we have the total yards overhaul for the cut.

In connection with office work the question of estimates may be considered. At the end of each month the engineer is expected to furnish an estimate of the amount of work done during the month. Most companies have a prescribed estimate form which should be filled out neatly, keeping everything in order of chainage. Quantities may be somewhat approximate for monthly estimates; but the approximations should not exceed the possible. Along with the estimate sheets a progress profile should be sent, showing the excavations moved and the embankment constructed during the month. This profile should be an intelligent history of the progress of the work, showing length and kind of structures; date work was begun and finished; road and farm crossings graded; notes as to the character of the soil and any other data tending to give a complete knowledge of the work in progress. Final estimates should be made upon the same manner, but should contain only exact double-checked quantities.

We have now completed what might be called the theory of this branch of engineering, and pass on to the supervision of the work of construction.

Apart from the actual grading, the most important consideration is that of drainage. The engineer should see that not only is the railroad right-of-way properly drained but that the land owners on both sides get a fair deal. It often happens that the work of construction destroys what is known as natural drainage, thus throwing the water off one person's land onto another

property. Each case which comes up requires a different remedy and all that can be said is that judgment and patience are the chief factors in obtaining a well-drained line from the company's as well as from the land-owners' standpoint.

When water is to be drained across the line we use a culvert of some form, of which we will mention several styles. Pipe culverts are largely used and are made in sizes from 6″ to 36″ diam. They are of two main styles, concrete (smooth joint) and burnt tile (bell point). The former is preferable on account of having a smoother outer surface when laid, thus lying flatter and keeping its alignment better. Tile pipe costs when laid about $1.25 per foot (24″) and concrete somewhat more. When double pipe are used they should be laid in separate trenches with a 6″ dividing wall. Cedar box culverts consisting of 10″x12″ cedar timbers (dressed on three sides) laid one on the other and spiked together form a cheap and easily made culvert. Such culverts, while not having such a long life as pipe, last for over fifteen years, in some cases without repair. Built cedar culverts of this type cost from $42 to $45 per 1,000 feet of timber including spikes. Many companies in reconstructing their lines have made use of concrete arch culverts. These will cost about $12 per cubic yard of concrete and give a practically everlasting article. A four bent trestle is frequently used where streams of twenty feet cross the line. These may be either pile or frame bent and where piles cannot be driven mudsills may be used to support the bents.

All culverts should be laid out with a level and have a slope of at least 5-10′ in their length.

Fencing should be started as soon as possible after grading commences, or better even before, thus saving much damage to crops in the vicinity, due to carelessness on the part of the contractor's men. The woven wire fence is largely used at present and gives entire satisfaction if properly erected; that is, it should be strung tightly and remain so. Posts should be sunk 3½ feet in the ground and well tamped with earth. To keep the fence from sagging the ends of each separate stretch of fence should be braced and where the stretch is long intermediate braces should be put in.

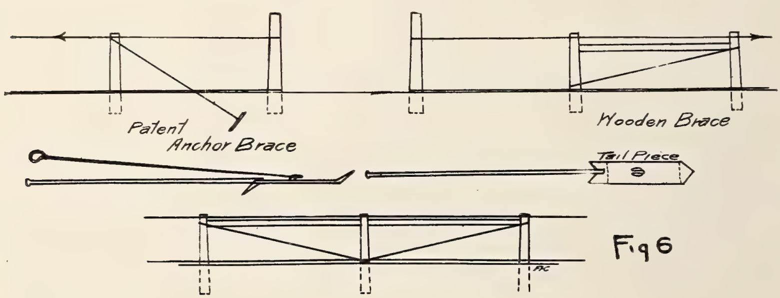


Fig 6

Fig. 6 shows a patent anchor brace in use. The tail-piece is driven into the ground with an iron rod. When the rod is removed and a strain placed on the twisted wire the tail-piece turns to a position at right angles to the wire, thus preventing its being pulled out of the ground. It will be noted that instead of bracing the gate posts as is often done we brace the next post away on each side, thus leaving the gate post free to hold up the gate alone. Wooden bracing is also shown in coincidence with wire and will be found to act most efficiently if placed horizontally instead of laterly.

Where the right of way cuts a farm into two parts, the owner generally has an agreement by which he gets a farm crossing over the grade. These must be graded with the rest of the work and have an extra 1′.5 to allow for ballast, etc., on the line.

It sometimes happens that enough material cannot be obtained from line cuttings to make a certain fill and so a borrow pit has to be opened. In side borrows a berm of 4 feet at the toe of the slope and 3 feet at the fence should be left. The engineer should be sure that a borrow is not made unless necessary, for if after the fills have been made and a balance is left in the cuts this will have to be washed. It sometimes happens that waste is unavoidable and in this case the material should be used to widen the dump below grade.

In some cases the embankment may run alongside a river or lake where, if it is of earth, may be damaged or washed out. This danger is overcome in some cases by rip-rap, which may be of two kinds—loose and hand-laid. The former is made by simply rolling large stones over the bank and allowing them to pile up at the bottom of the slope. The latter consists of flat stones laid one on the other, thus forming a wall four or five feet in thickness and running the length of the endangered line. Timber cribs are sometimes built and when filled with stone prove very effectual as a protecting wall.

All bush and timber must be removed from the right of way and stumps (in fills between 4′ and 1′.5 in height) must be sawed down close to the ground. Those in cuts under 3′ and fills under 1′.5 must be grubbed out by the roots and will be paid for by the acre.

Where a cut contains a number of different kinds of material it must be classified, that is the percentage of each class of material judged. Different specifications call for different requirements defining each class, so all that can be said is that the specifications should be interpreted upon the broad grounds of common sense and professional intelligence.

When grading is finished the engineer should run track centres, picking up the line from his reference hubs. Small equations in chainage no doubt will be found and should be run through to the end of the section. A final transit book should be filled out showing correct chainage of all hubs and their permanent reference marks.

Having dealt, in some detail, with the duties of a resident engineer on construction, it remains but to add that the engineer is employed by the railroad company to protect its rights and to enforce the ruling of the contract in such a way that the contractor gets a fair deal. The engineer is to be the sole judge of the interpretation of the claims of the contract, and it is his business to see that quick, thorough, business-like judgment is given in all cases. He must treat the contractor in a business-like manner if he expects business to be done. The contractor is there to make all he can out of the job and the engineer must endeavor to help him in this with the contract as the bounding limits.

A NEW APPARATUS FOR MAKING CARBONIC ACID GAS

*J. A. DECEW '96,

An improved apparatus has been devised with the object of utilizing to the greatest possible advantage, the well-known property of an alkaline liquid, such as potassium carbonate, of readily absorbing especially under pressure, carbonic acid gas and so forming a bi-carbonate. This bi-carbonated solution when boiled gives up the carbonic acid with which it has been saturated, and is, during and after cooling, again ready to absorb CO_2.

The raw material employed is carbon, in the form of coke or charcoal, and the furnace gases, resulting form its combustion, containing about 20 per cent. of carbonic acid gas, are used for bi-carbonating the liquors.

The cleansed furnace gases are forced successively through bi-carbonaters in such a manner that during their passage through the lye in the bi-carbonaters, practically all of the CO_2 they contain is absorbed by the lye, and what escapes is merely residual inert gases with a little steam. The process is termed bi-carbonating.

Simultaneously, with the process of bicarbonating, there is another and opposite process of de-carbonating going on in another portion of the apparatus. Here the bi-carbonated lye is heated in a suitable boiling-off vessel by steam or otherwise, to a temperature of 212 degrees F. and higher in order to decompose the bi-carbonate which it contains. The CO_2 thus released passes through a suitable gas cooler to a gas holder, whence it is drawn for use. The supply of gas to the gas holder is easily

---

* Chemical Engineer, Montreal.

regulated by increasing or decreasing the lye or heat supply to the boiling-off vessel.

It will be noticed that these two processes, although they go on at the same time, are not only independent of each other, but also opposite in result. Upon their completion the lye in the bi-carbonator has become saturated with CO_2, while the lye in the boiling-off vessel has been freed from CO_2.

These operations constitutes a complete cycle. They are controlled by means of suitable valves, the operation of which is effected by rotating a hand wheel, so that all that the attendant has to do, when the time comes to change from one of these operations to the next, is to turn the hand-wheel. With this simple method of control, there is no possibility of an accident, nor of the CO_2 produced being anything but pure and free from air.

The yield of carbonic acid gas is extremely satisfactory, for of the 20 per cent. contained in the furnace gases from coke suitably burnt, the apparatus extracts practically all. In quality and odor the CO_2 produced is excellent, being better than that obtained from whiting, agreeable to the palate and free from twang.

An important feature of this new process is its use of pressure to accelerate absorption, and so to reduce the space occupied by the plant. Unlike any other process for producing CO_2 from coke, it puts the furnace gases under pressure before passing them through the lye, thereby rendering it possible to use a lye of much more than usual strength, with a corresponding increase of speed in carbonating, and decrease in the size of the vessels.

Pressure is also utilized in this plant, to minimize the number of moving parts. Instead of employing a pump to circulate the lye, as is usually done, the inventor has taken advantage of the fact that the temperature required to decarbonate the lye can also be used to produce in a confined space, Pressure sufficient to force that lye from the lowest to the highest vessel of the apparatus, the remainder of the lye circulation being effected by gravity.

As contrasted with the method of producing CO_2 from chemicals, this process offers distinct advantages. It requires no sulphuric acid, which is always a dangerous article to handle, and liable, as is well-known, to contain arsenical impurities. Nor is there any chance of contamination as with whiting, since the lye employed is not at any time exposed to contact with anything except washed and cleansed furnace gases. Nor are there any objectionable bye-products, such as sulphate of lime, to dispose of.

Once the appartus has been adjusted and started, it requires merely its daily supply of good coke, than which nothing is less subject to impurities, and water for washing and cooling the furnace gases and for cooling the CO_2.

In economy, in cost of raw material, this new patent apparatus is signally successful. The manufacture of one ton of CO_2 from acid and whiting involves a consumption of raw material, which costs in England, where the process is in operation, about $70.00, (seventy dollars), whilst the above plant consumes only eight hundredweight of coke, costing about $2.50, in producing the same quantity of gas. The factory, labor and adminstrative charges being about the same in each case, there is an average gross saving of $67.50 per ton of CO_2 produced. Allowing, however, for the maintainance of the plant, and for conditions where the operator does not work his plant to its full capacity, he yet makes on an average a saving of $25.00 to $40.00 per ton, according to the size of his plant. By replacing old plants with this system an annual saving is made which will amount to 70 to 100 per cent. upon the investment.

The apparatus can be built in sizes having a daily capacity of from one hundredweight to five tons, and would be serviceable to all makers or users of pure carbonic acid gas.

MEASUREMENT OF INDIVIDUAL RESISTANCES IN A NETWORK

T. R. ROSEBRUGH

The problem sometimes arises of finding the resistance of one or all the conductors connected to each other at certain points.

These points may be termed branch points, and if sufficiently numerous, the whole group of conductors so connected may be appropriately termed a network.

In some cases the arrangement is accessible throughout and any desired conductor may be isolated for measurement, so that no new problem is presented. In others, as for instance, insulation resistances, it may not be possible to do anything of the kind. This leads to our problem.

For example, suppose in a building there are three mains with branches nominally insulated from each other and from ground ; we may consider it possible that some conductance is present between each of the wires and ground (three paths), and between the three wires (three paths).

These may be indicated diagrammatically as in Fig. 1, A, B, C and D representing respectively the three wires and earth.

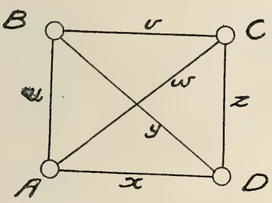


Fig. 1

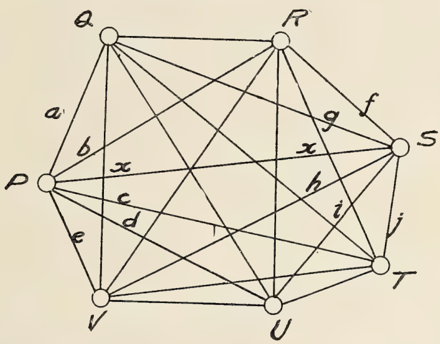


Fig. 2

A principle may be employed for determining these resistances (or more conveniently their reciprocals, the conductances) which can perhaps be better understood in the case of more numerous branch points.

If seven branch points be selected as an illustration, the diagram will be as shown in Fig. 2.

Suppose now that these branch points are all accessible and that we can join any of them we please together by a wire whose resistance may be neglected in comparison with the resistance to be determined, we may then proceed as follows :—

(a) Short-circuit together all but P, and measure the conductance between this group and P. Call this p.

(b) Short-circuit together all but Q, and measure the conductance between this group and Q. Call it q.

(c) Short-circuit together all but P and Q, and measure the conductance between this group on one side and P and Q united on the other. Call this $\widehat{pq}$.

Let the unknown conductances have the values marked in Fig. 2.

Then
$$a + b + x + c + d + e = p$$
$$f + g + x + h + i + j = q$$
$$a + b + c + d + e + f + g + h + i + j = \widehat{pq}$$

Therefore
$$x = \tfrac{1}{2}(p + q - \widehat{pq})$$

Applying the same notation for the conductances measured between points and groups, and lines and groups to Fig. 1, the following results may be written down from inspection.

$$x = \tfrac{1}{2}\,(a + d - \widehat{ad}) = \tfrac{1}{2}\,(a + d - \widehat{bc})$$
$$y = \tfrac{1}{2}\,(b + d - \widehat{bd}) = \tfrac{1}{2}\,(b + d - \widehat{ac})$$
$$z = \tfrac{1}{2}\,(c + d - \widehat{cd}) = \tfrac{1}{2}\,(c + d - \widehat{ab})$$
$$u = \tfrac{1}{2}\,(a + b - \widehat{ab}) = \tfrac{1}{2}\,(a + b - \widehat{cd})$$
$$v = \tfrac{1}{2}\,(b + c - \widehat{bc}) = \tfrac{1}{2}\,(b + c - \widehat{ad})$$
$$w = \tfrac{1}{2}\,(a + c - \widehat{ac}) = \tfrac{1}{2}\,(a + c - \widehat{bd})$$

It will be noted that $\widehat{ad} = \widehat{bc}$ (and similar equalities) because they are two different designations for the conductance measured in the same experiment, namely from A and D joined to B and C joined.

From the above it appears that seven measurements of conductance, namely
$$\left.\begin{array}{l} a,\ b,\ c,\ d, \\ \widehat{ab}\ \widehat{ac}\ \widehat{ad} \end{array}\right\}$$
are sufficient to determine by symmetrical formulae the six unknown conductances x, y, z, u, v, w, and the corresponding resistances may then be found by taking reciprocals

A little further examination will also show that seven measurements also furnish the check

$$a + b + c + d = \widehat{ab} + \widehat{ac} + \widehat{ad}$$

In the practical application of this method apart from the precautions necessary to secure good measurements of somewhat variable electrolytic conductance (when measuring insulation) it should be kept in mind that relatively small conductances will be given as the difference between quantities each of which is the sum of several larger quantities, hence accuracy should in such cases not be expected.

GOLD DREDGING

W. F. WRIGHT, B.A.Sc.

The gold dredging industry, which is, in itself, one of the most prosaic imaginable, has been a gradual evolution with its beginning in the romantic placer mining, where two miners used pick and shovel and hand screen, and barely made an impression on the same large fields which are now being worked by the aid of large power dredges. Probably the main reason for the present-day lack of interest is due to the fact that dredging is never begun until a preliminary examination has shown the actual values, and then the profits are a sure thing and only of interest to those financially interested in the proposition.

Gold dredging was first begun in New Zealand, where the pioneer miners dredged the sandy bottoms of the Molyneux River with leather bags riveted to iron hoops on the ends of long poles.

About the year 1867 steam power was used to operate a chain of these buckets, and as their capacity was increased they were made out of iron. About five years after this the dipper dredge was introduced, and has been itself gradually displaced by the continuous bucket dredge. The reasons for this will be given later.

At present there are over 300 dredges in operation in New Zealand; about 60 or 70 in California, and others scattered throughout the West in Montana, Colorado, Idaho, New Mexico, Oregon, British Columbia, Mexico and South America.

There are three types of modern dredges:

1. Section pump.
2. Dipper or single bucket.
3. Continuous bucket.

The suction pump is very satisfactory for shallow fields with sandy soil, but is very liable to lose a great deal of the gold, as it cannot remove boulders which lie along bed rock where the deposits of gold are heaviest.

The dipper dredge was for many years the favorite, as it had been very highly developed for marine work and could be relied on for continuous service, but it was far from an ideal machine. Some of its disadvantages were:

(1) Its small output considering maximum power required.

(2) The agitation of the water due to the irregular operation caused great losses of gold values.

(3) Irregular operation of the gold saving devices due to the intermittent dumping of the buckets.

(4) Great trouble of washing and disintegrating the great masses of material when clay is present.

Dipper dredges have been built with a capacity of 30 to 33 cubic feet per dip, but owing to the long intervals between operations the monthly capacity is small, and the bed rock is not thoroughly

cleaned, as the operator can hardly guide the dipper to the exact spot where the last shovel full is taken out.

The continuous type of dredge appears to be as near perfection as can be obtained, but is itself constantly undergoing improvement, so that one would hesitate to predict the details of the dredge which will be used in another ten or fifteen years.

The buckets are from 3 to 14 cubic feet capacity, and their arrangement extends to a certain extent on the nature of the field. A gravel or sand bed is best worked with a close bucket dredge, while clay and rocky fields are more easily handled with dredges of the bucket and link type. Dredges of even moderate capacity will handle boulders weighing nearly a ton without great difficulty, and will dig a distance of 30 to 45 feet from the water level to bed rock, and by elevating the tailing conveyor another 30 feet can be obtained, so that a total depth of 70 feet can be handled. The speed of the bucket line is 45 feet per minute average. A 5 ft. dredge will handle 75,000 cubic yards per month. The digging apparatus has been so highly developed that the capacity is practically limited by the washing apparatus.

The washing apparatus consists of a shaking or revolving screen, riffles and quick-silver on the sluices or cocoa matting with expanded metal mesh on the sluices, and either a belt or continuous bucket conveyor for disposing of the tailings. Water is furnished by centrifugal pumps for washing the boulders and disintegrating the clay.

All the early dredges were steam operated, but the modern tendency is towards electric power, which can generally be cheaply obtained from water powers within a reasonable distance of the fields.

Electricity gives a much cleaner and more pleasant power than steam, and is in a great many cases less costly, and its great reliability obviates many delays which, in this industry, are the greatest loss.

The power required for a dredge varies, of course, with the different conditions, but a small dredge, i.e., 5 cu. ft. dredge, requires about 130 h.p., while the larger sizes require about 400 h.p., divided as follows:

Main bucket drive	200 h.p.
Centrifugal pump for washing	75 h.p.
Winch motor	35 h.p.
Sand pump	75 h.p.
Stacker motor	25 h.p.
Auxiliary pump	15 h.p.
	425 h.p.

These amounts vary also with the various makes, but represent a fair average.

One ordinary dredge requires a crew of about eight men and operates on an average from 16 to 18 hours per day, and cost ap-

proximately six cents per cubic yard for excavating, and the loss in gold in the tailing is not over about ten cents per cubic yard, so that any property showing over forty cents on prospecting can be worked at a good profit. A great many fields show values averaging at least one dollar per cubic yard.

Prospecting is generally done with a drilling machine, which sinks a hole about seven inches in diameter. A hole to every ten acres is considered close prospecting, and by actual experience it has been found that about 70 per cent. of the values obtained in prospecting can be realized.

When the ground is frozen it is necessary to use steam to thaw the ground. "Steam-points" are driven into the ground about eight or nine feet apart, and the same distance from the face of the bank and moved along as the work progresses.

NEW PHOTOGRAPHIC PROCESSES

G. R. ANDERSON.

Great interest has been awakened in photographic circles within the last few months by the announcement that the firm of Lumiere & Sons had perfected a new screen plate for the production of transparencies in color. These plates have lately been tried in the photographic laboratory and the results already obtained confirm the claims put forth by the manufacturers. The color screen consists of a layer of starch grains, stained red, green and blue-violet sifted over a plate previously coated with a retaining substratum, and over this layer of colored starch is then spread a panchromatic silver emulsion. The plate is exposed reversed in the camera so that the light passes through the screen to reach the sensitive coating. To reduce the action of the blue and violet light a medium yellow screen is used similar to that employed with the common orthochromatic plates.

Development is carried out as usual, after which the negative is converted to a positive by the action of potassium permanganate. It is then re-developed, intensified in a silver bath and fixed. The operations although numerous are quickly performed and a slide may readily be shown on the screen within an hour after commencing operations.

As might be expected, the plate is comparatively slow owing to the combined action of the yellow screen on the lens and the color screen contained in the plate itself, the exposure required being apparently about forty times that necessary for a rapid plate such as Seed's or Cramer's. If the exposure is correct the colors are reproduced with remarkable fidelity; under-

exposure gives a somewhat bluish tinge to the image while over-exposure results in a pink.

Since every portion of the plate is overlaid with a layer of starch grains, it is evident that an "autochrome" slide will appear denser than an ordinary one of the same subject, for in the latter case the whites of the picture are but clear glass whereas in the color slides the white portions result from an equal mixture of red, green and blue light passing through the corresponding colored grains which are only partially transparent. If the projected image is 35 or 40 times the size of the slide the grain of the plate becomes apparent at close range and detracts somewhat from the effect; for this reason and also on account of the greater density better results are secured by arranging the lantern for a smaller image than is ordinarily used, say five or six feet.

Compared to the older tri-color process with three separate negatives and three corresponding positives or the modified triple line screen plate process of Joly, the Lumiere method is vastly superior in ease of manipulation, certainty of results and superiority of rendering, and must necessarily prove of the utmost value in scientific work where color rendering is important.

Carbon workers will be interested to learn of the invention of a new tissue of much greater sensitiveness than any already in use. This paper, known as Carbograph, is manufactured by the Rotary Photograph Company, of London. The coating consists of the ordinary pigmented gelatine incorporated with a bromide of silver emulsion, by which a speed of from three to five times that of rapid gas light paper is attained. This speed renders the paper available for direct enlargements either by daylight or the electric arc, and as the negative may be reversed in the enlarging camera the very troublesome operation of double transfer is avoided.

The manipulation is as follows: After exposure the paper is developed, preferably in a ferrous oxalate developer and after a short immersion in an acid bath is sensitized in the usual bichromate of potassium solution. It is then given a short washing and squeezed to its support, and after a short interval the final development takes place in warm water as in the ordinary carbon process. When the latter development is completed the paper must be immersed in a hypo bath to remove the unaltered silver bromide. It is evident that the image will consist of reduced silver from the silver bromide emulsion and the pigment incorporated with the gelatine.

The paper possesses two notable advantages, viz., its very much greater rapidity and easier manipulation and the greater strength and brilliancy of the image. For the ordinary carbon process negatives of great contrast are required since the print is always very much softer than the negative, but with the Carbo-

graph paper such tests as have already been made in the laboratory show that vigorous prints may be obtained from relatively thin negatives. Should the print appear to possess too great contrast the silver may be reduced or entirely eliminated by a ferricyanide reducer or if it is too weak an intensifier may be used as in a bromide print or negative. To those who wish to make carbon enlargements the paper will prove especially serviceable and of course it may also be used for contact printing although in this case either a reversed negative or double transfer is necessary.

PLANE TABLE TOPOGRAPHY

W. TREADGOLD, 04

In most all topographic surveys covering an extended stretch of country, in order that the topographer may have points definitely fixed in position and in elevation which will control and guide him in his subsequent work, a system of triangulation is carried out. The work of primary triangulation and its expansion from a base, consists in the selection of stations, in the erection of signals and in the measurement of angles. Stations are so selected as to give a commanding view of all the surrounding country, to give well shaped triangles and so as to group these into simple quadrilateral, pentagonal or similar figures. They are also so selected as to serve best the needs of the topographer. This requires that they shall offer suitable bases from which to expand the secondary triangulation and that at least two, preferably three, points shall fall within each sheet used in plotting.

The primary triangulation being completed, a preliminary computation of the positions and distances between stations is made in the field and these data are furnished the topographer as a basis on which to construct his graphic or plane table triangulation. From this point forward, all the work is represented on the plane table sheets, thus requiring the keeping of no cumbersome notes which must be worked up at some future time in the office, while the progress of work from day to day is always observable.

Having, then, located a sufficient number of points, properly distributed over the area to be surveyed, which form a strong framework for controlling the accurate location of the various details, the topographer is then in a position to proceed with the secondary triangulation which is made by means of the plane table.

The plane table is composed of a well-seasoned drawing-

board about 30 inches in length, 24 inches in width, three-quarters of an inch thick, with bevelled or rounded edges. It is commonly made of several pieces of white pine, tongued and grooved together, with the grain running in different directions to prevent warping. It is supported upon three strong brass arms to which it is attached by screws passing through them and entering the underside of the board. It is connected with the tripod by means of a ball socket joint. When loose this permits of the board being revolved in a horizontal plane about its centre and when clamped holds the table firm. The board can be levelled by means of levelling screws, two cross levels being placed on the board and shifted until at any position it appears level. The tripod and board should be designed so as to be neither heavy nor cumbersome (a common fault with many patterns) yet combining the elements of stability, lightness and firmness.

The type of alidade in general use consists of a brass or steel rule, nickel plated underneath, from and perpendicular to which rises a brass column (3 inches high), surmounted by Y's, receiving the transverse axis of the telescope, to one end of which axis is firmly attached a graduated arc of 30°, each side of a central 0°, an accompanying vernier being attached to the lower end of the Y support. The arc moves with the telescope as it is raised or depressed and it is used in the measurement of the vertical angles from which height is determined.

A clamp and a tangent screw placed on the other side of the telescope, opposite the arc, controls its vertical movement. The eye piece carries the usual diaphragm, with screws for collimation adjustment, which has one vertical and three horizontal wires. The horizontal wires are used in order that stadia readings might be taken and so points of detail at once located. The telescope is mounted firmly on to the ruler as by the method of location of points employed no readings of horizontal angles are necessary.

Each plane table sheet is complete within itself, and on it little is recorded other than the graphic triangulation and a little sketching of the immediate summit of the hill occupied. From the standpoint of efficiency the plane table sheet is the least satisfactory portion of the equipment. It is very susceptible to atmospheric changes, expanding and contracting unceasingly. This might be overlooked if this were the same in all directions. But the objectionable feature arises from the unequal expansion and contraction which changes the relative distance and direction of the points. Various substitutes have been tried but none have proved entirely successful.

To reduce the distortion the sheets of paper used should be thoroughly seasoned before taken to the field and this is effected by exposing it alternately to a very damp and very dry atmosphere. Two sheets of paragon paper are often employed the size of the plane table board, mounted with the grain at right angles and with cloth between them.

Besides the chief topographer in the party there is always an assistant whose usefulness to his chief is limited only by his skill and experience. The logical inference being that he is in training to become a topographer himself, he takes charge of an increasing share of the work as he becomes more and more familiar with the methods employed. This enables the chief to turn his attention in other directions, which will expedite the survey and increase the amount of work done. Two rodmen are needed and the rapidity with which the work is carried out depends upon their efficiency. When well trained they should be able to recognize the salient points of the features of the ground to be mapped, so that the topographer can draw in correctly the details from the least possible number of readings.

The work involved in the carrying out of a survey might reasonably be classified under three heads:

1. Plane table work proper, involving exact location of points, in plan and elevation, of the secondary triangulation.

2. Detail work, including traversing of roads by means of a light plane table and cross country traverses by means of the stadia.

3. Sketching of the map.

1. Plane Table Work.—On taking the field the topographer has, in addition to the triangulation points accurately plotted upon his plane table sheet, all such data as he has been able to gather from railway surveys, city engineers' offices, county surveyors or from state or national organizations, so that he is able to make best use of such material as has been obtained from prior surveys, examining and checking this in the field in order to assure himself whether it is sufficiently correct for adoption. A reconnaissance of the country should then be made for the purpose of recovering triangulation stations and to locate signals at suitable points for subsequent determination and use. The object of this work is to locate a sufficient number of points to enable the traverse man accurately to tie in his traverse surveys which are made for the purpose of gathering together detail. The chief method used in determining these points is that of intersections. It requires some little experience to decide which are the points worthy of location and having decided to fix them in the mind so that they may be recognized and located from another station. Besides they must be described sufficiently that the traverse man may identify them with locations of his own. After signals, which are of a temporary character consisting usually of a properly braced rail or pole from 10 to 15 feet high on which a cloth flag about one yard square is fastened, have been erected, the topographer then proceeds to occupy each of his stations in succession, obtaining intersections upon other chosen stations and upon all such objects as hilltops, lone trees, church steeples, houses, etc., as will probably be seen and identified from other stations. He also reads and records vertical

angles to all these objects, so that when his secondary triangulation is completed his plane table sheet has located upon it a great many natural and artificial objects, the vertical elevations and horizontal positions of which are recorded.

2. Detail Work.—On an extended survey while the secondary triangulation is being made the assistants are carefully traversing all roads, etc. For this purpose they often use a lighter form of plane table, having no levelling apparatus, on which is a compass needle, the alidade employed being an open sight ruler about 10 inches long. With these instruments and with the aid of distances measured by an odometer on the wheel of the buggy or cart in which he rides, the assistant traverses every road in the area to be surveyed. He sights to natural objects in the road, usually a sharp bend, orienting his board by means of the compass needle. He sets up his instrument at every other station, taking fore and back sights, and plots frequent lines to the prominent objects about him, as hilltops or other salient features, which he thinks the topographer may locate. In this way he obtains a means of connecting his work with that of the topographer, more especially as he locates all houses on the line of his traverse and the topographer intersects on many of these.

In the writer's opinion it would be just as cheap and easy to make the traverses throughout by the stadia method. All detail could be obtained in that way. The instrument man could set up at a known point of the secondary triangulation, carry a traverse line across country, in the meantime locating prominent and characteristic points by a single reading, finally checking up on the first convenient point of triangulation that comes within reach. It has been demonstrated time and again that the method is economical and gives, with sufficient care, any degree of accuracy that is required. With the small plane table it is necessary to keep to the open roads and these as a rule are not found in the greater part of the country of which a topographical map has to be made. Where bodies of water and rivers are to be surveyed this is the only practical method that can be used. If the country is of such a character as to be lacking in prominent and characteristic features and of a regular easy sloping surface the use of stadia readings is to be highly recommended.

3. Sketching of the Map.—Now the topographer has on his map the positions and elevations of all points of both his secondary triangulation and stations along the different traverses. These give him rigid control over all sketching work which remains to be done. He starts at any point of a road or traverse and makes a small circuit, sketching as he goes the real shape of the ground, checking his levels by means of an aneroid, assuming of course that the elevation of his starting point is known. He sketches these contours in as far as he can follow them, on each side of the road, using the points located by the road traverses and

plane table to check his bearings, distances and elevations. This work is greatly assisted by numerous locations off the road in the proper places and the traverse man would do better to have too many auxiliary points than too few. It is by far the most difficult part and to sketch well a great deal of experience is necessary. The object of the work is seen at a glance. Practice and in most cases a great deal of practice, is the only means which will enable one to arrive at the desired result.

The United States Coast and Geodetic Survey have used this method almost entirely in the carrying out of this great work throughout the United States and the results have been very successful in every part except the very rough, inaccessible, mountainous country. In the marking of the boundary between the United States and Canada on the 49th parallel in British Columbia, it was decided by a joint boundary commission that the work should be done by each government in alternate sections, each section to overlap by almost a mile or so. The method used for the work by the United States was of course the plane table and that used by the Canadian Government parties, that of photographic surveying, so that when the maps are complete it will be interesting to compare the amount of accuracy and detail obtained by one method when compared with the other.

THE COMMERCIAL SIDE OF ENGINEERING

K. L. AITKEN, Consulting Engineer.

My remarks this afternoon will be almost entirely from an electrical standpoint, and it is my intention merely to touch on the principal features of what I call the "commercial side" of engineering.

At present, the word "engineer" may be defined as "a person versed in the commercial and practical application of the sciences." Electrical engineering is truly a commercial pursuit, for the field has reached its present magnitude solely through its money-making properties. This is borne out by statistics; for instance, in the year 1905, in the United States alone, apparatus and supplies were purchased to the extent of $210,000,000, and electric railway, lighting, power, telephone and telegraph industries yielded a gross revenue of $720,000,000. These figures are conclusive.

There are two primary branches in electrical work, namely, manufacture and utilization, and it is worthy of note that with a few brilliant exceptions, there are no engineers at the commercial head of these industries to-day. This is a condition

which should not exist, for the engineer's education should broaden him and fit him for such responsibilities.

When a young man leaves his Alma Mater, with a diploma stating that he is this kind or that kind of an engineer, he usually has the firm conviction that his education is complete and that he is an expert in every sense of the word, whereas, it has been stated, by our good friend, Dr. Galbraith, I think, that a college can give a man a foundation of knowledge only, and that his real, his important education, does not commence until he is out in the world.

Some eight years ago, the Testing Department of the Sprague Electric Company frequently took in graduates from the New York universities. A few of these men were all right, but the great majority were almost hopeless. They did not seem able to grasp the idea that they were paid to get the work through the shop—they had large, cumbersome, and utterly impractical ideas on the commercial testing of motors and generators. These men may have known a good deal about the sciences of electricity, in fact some were not in the least backward in making statements to that effect, but they lacked utterly the commercial idea, and hence, so far as promotion was concerned, they were their own worst enemies.

I think the trouble lies in the fact that the young man in college is rather too apt to consider that things commercial are beneath his dignity, and I wish to say, therefore, with reference to this mistaken idea, that if he ever hopes to make money out of his profession, and this, I presume, is a rational desire, he will have to acquire early in his career a thorough grasp of the underlying principles of business.

When an engineer is assigned to a certain piece of work, he must appreciate the object of that work, and must know how to achieve that object with a minimum expenditure of time and money. In valuations, you may be able to inform a prospective buyer of all the technical characteristics of a certain machine, but he does not care about such things. He does not understand them and has no wish to, but he does want to know how much the machine is worth to him in money for the purpose he intends using it, what other machines of the same class have been sold for, and what market exists should he wish to re-sell. The capitalist who is desirous of entering into the business of electric lighting and power says: "Here is a city, and there, I understand, is a water power. Advise me on the possibility of establishing a plant." Your report under such circumstances must be simple and to the point, and must show a thorough understanding of the commercial end of this class of business. Otherwise it will carry no weight. If you insist upon including a long and complex dissertation on alternating vs. direct current transmission, your client must surely get the impression that such action is at the expense of the practical side of the situation.

Switchboard design is a matter upon which engineers are prone to spend money uselessly. The purpose of a switchboard is specific, and hence it must be simple, the incorporated apparatus must be reliable, and yet, withall, the first cost must be kept down to a minimum point. Complicated switchboards are a prolific source of accidents, both to persons and to apparatus, and hence for this reason alone, are things to be avoided. The earning power of a plant is in no way increased by the installation of an elaborate system of panels, and it is with earning power that we are concerned.

Young engineers are apt to worry uselessly over matters foreign to the subject in hand, and only practical experience can cure this evil. I remember some years ago when a small transmission system was being designed, the engineer became cognizant of the condition known as resonance. This bothered him considerably, for its possibilities appeared unlimited, and he really knew nothing about the subject. About this time an engineer of international reputation delivered a lecture on transmission, and among other questions he was asked what provisions he had found necessary for the prevention of resonance His reply was to the effect that he had never heard of any transmission line where trouble had been experienced from this source, and hence he did not bother much about it. When our young engineer heard this, he was much relieved, and very properly dropped the matter forthwith.

Short cuts have their place in business and hence in engineering calculation, and therefore, at this juncture, it will be well for us to give consideration to the slide rule, a very much abused, though decidedly useful instrument, Like the hand level, it is quick and fairly accurate, and consequently, in your commercial life, you will find it of great value. But do not try to make it accomplish things for which it was never intended—where accuracy is essential, fall back on pencil and paper, and use the slide rule as a check. Learn to use it carefully, but do not get the habit too badly. Remember that a man's brain is capable of making simple calculations. Mr. J. G. White once remarked that nothing annoyed him so much as to have one of his high-priced engineers pull a slide rule out of his pocket and say that two tons of steel rails at $33.00 per ton would cost approximately $65.00.

Too much attention to the scientific end, and too little to the business end, renders an engineer impractical, and hinders him in the proper handling of men. This is a most important matter, and without it the engineer can never become prominent in the commercial or "large salary" end of the art. He is bound to come into close personal contact with both his subordinates and his superiors, and his success depends to a great extent upon his ability to get along with these two classes.

It is in the selling of appartus that the business end of an engineer's education plays the most important part—really I

think his very existence as a salesman depends upon his grasp of commercial principles, and also upon his knowledge of human nature.

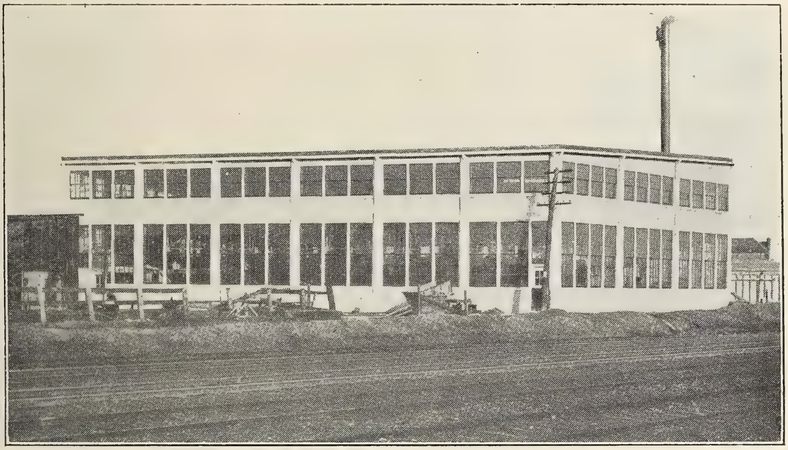
While I have this opportunity, I wish to give you my ideas on the subject of engineering training. My own opinion coincides with that of Dr. Galbraith, namely, that the college can supply the foundation only. You have the opportunity now of laying that groundwork well, and I can tell you honestly that if you neglect it in college, you will have no time to complete it after you commence to earn your living. Therefore, I say to you, devote every moment of your college course to the building of a foundation capable of sustaining the practical experience which will come to you in later years.

I believe that the last two years of the college course are of vast importance, and I think therefore that every student should fit himself, so far as it is in his power, to thoroughly appreciate the work of his third and fourth years. To this end I would say that the ideal education consists of two years of college, followed by an equal term in the shop of some large manufacturing concern. This latter period will instill, to a certain degree, a sense of the commercial fitness of things, and then when the third and fourth years of college have finished the foundation, the student will leave his university with a wholesome and proper idea of his own smallness, which, I assure you, is a very desirable state of affairs, after graduation. I think another year in the shops and a year of erecting work, will be found of great value. Then there should come, as a coping-stone, at least two years as a salesman, and if our student has been successful throughout all this miscellaneous work, we may safely say that he has found himself. He will seek responsibilities and acquit himself with credit, and he will appreciate the major importance of the commercial side of engineering, the side which I really believe is the backbone of the whole business.

*SOME FURTHER COSTS ON CONSTRUCTION OF CONCRETE FACTORY BUILDINGS

D. C. RAYMOND

In answer to your request that I submit additional data regarding labor in the erection of the McGregor, Banwell Fence Co.'s factory, the following information may prove of interest:



McGregor, Banwell Fence Co., Walkerville, Building Completed

Building runs, hoisting and mixing concrete—		
Engineer, 378 hours at 25c.	$ 94.50	
Laborers, 3826 hours at 17½c.	669.52	
Carpenters, 308½ hours at 35c.	107.98	
		$ 872.00
Placing and tamping concrete—		
Laborers, 3211½ hours at 17½c.		562.00
Placing reinforcement—		
Laborers, 1263 hours at 17½c.		221.00
Stripping centering, and cleaning up—		
Carpenters, 420 hours at 30c.	$126.00	
Laborers, 1451 hours at 17½c.	253.93	
		379.93

*The receipt of two letters on about the same mail, one from New York, the other from San Fancisco, asking for the above information, showed not only how widely APPLIED SCIENCE is read, but convinced us that the information is desirable.—Editor.

Carpenters building and setting forms—

Carpenters, 4700 hours at 35c.	$1,645.00	
Carpenters, 1212 hours at 30c.	364.50	
	———	2,009.50

Superintendence—

Foreman, 44 days at $6.00	$264.00	
Company's supt., 2½ months at $100 ..	250.00	
Engineer, inspecting, including traveling expenses re same	200.00	
	———	714.00

By an arrangement with the owners, we employed as many of their factory hands as possible at 17 1-2 cents an hour. Their former building was destroyed by fire and the firm desired to keep as many of their old hands employed as possible. The carpenters were paid 35 cents an hour, with the exception of a few at 30 cents.

I would like to call your attention to a typographical error in the former publication, under "Cost of Materials," the cost of centering, per cu. yd. should be $5.84.

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published Monthly during the College year by the University of Toronto Engineering Society.

Editorial

Provincial Forestry Policy.

During the first week of this month the existence of the Faculty of Forestry has received a testimony of justification which will rejoice every forester's and every patriotic citizen's heart. It came in the shape of an announcement by the Honorable F. W. Cochrane, Minister of Lands, Forests and Mines, to the effect that the Ontario Government proposes to inaugurate a more rational and conservative policy regarding the treatment of the timber resources. We are glad to see that conservatism is taking up a proper line.

The programme laid down includes an extension of the fire ranging system, an increase in the force of forest rangers who supervise the cutting on timber limits, and an extension of the forest reservation policy. The timber in the forest reservations is to be cut under special regulations, which, we suppose, means that they are to be placed under proper technical management of foresters.

And another important step proposed is to settle the rights of the timber license holders. These have by misconstruction of their contracts with the Government contended that they are entitled to everything growing on their limits, and the Government must by compromise or otherwise regain possession of its property.

It is also proposed to foster the reforestation of waste lands in the older parts of Ontario, where farmers are suffering from dearth of timber. Even Dean Fernow could probably not suggest any further steps, except perhaps that a technically manned department should be instituted to carry out these plans ,in which his students would find employment.

We congratulate the Minister on his statesmanlike attitude to this, Canada's greatest interest, and the Faculty of Forestry on the likelihood of early recognition of its students in Government service.

Widening of Technical Education

We hear considerable discussion these days on the subject of technical education. Our Boards of Trade and Labor Unions are taking the matter up. They know they want something, they realize that something is lacking under present conditions, yet they do not appear to be able to agree on exactly what they do want. At the same time we have our own men criticizing the course. This arises mainly because they do not understand the exact conditions and limitations of Engineering education. Engineering schools have before them a field which may be divided into three parts, two parts being semi-professional or completely professional and the third vocational and subordinate to the others. Our School has only occupied one effectively, though there is a tendency towards an occupation of the second. The three fields might be defined as follows:

(a) Engineering Research and advanced professional instruction which is being given here and there to a few graduate students, and which is still in its infancy in Toronto.

(b) The Engineering courses of study as they are now ordinarily planned.

(c) The instruction of artisans and especially instruction adequate to the need of industrial foremen. It is a debatable question that the time has now arrived that the province should step in and train such men for the manning of our industrial enterprises. It might be noted in passing that this three-fold field is already covered in the work of the Agricultural College

at Guelph. No one will deny that the money expended in any of the three portions has not been a splendid investment to the province.

Professor D. C. Jackson, of the Massachusetts School of Technology, in a paper read before the Society for the Promoting of Engineering Education, made the following statement:

"I lay this fact at the door of Engineering Schools and hold that the members of the Faculties are not guiltless unless they make adequate efforts to get filled this need in education for master craftsmanship in the industries which comes within the purview of their influence and direction."

The governing boards of the Engineering Schools must divide the guilt with the Faculties if they continue their common failure to provide sufficient teaching force in the Engineering department, thus putting any effort which reaches beyond the routine of the department record and touches the larger interests of the industrial body beyond the physical endurance of the individual members of the Faculty.

I believe that such views lead emphatically to the proposition that Engineering Schools are called upon to extend their influence so that they will continue their present work of education for the scientific engineer, advance the work of engineering research and advanced professional study, and also foster the establishment, maintenance and development of Polytechnic Schools for master craftsmen.

Culture in Technical Education

A contributor deals with the question of broadening the education of our graduates. He lays stress upon the personal training of the men. What he says cannot be easily denied. The graduate will find, more and more, after graduation that if he is to make a real success in life, he must deal successfully with men as well as with engineering problems. To do this, the better his mental equipment, the more certain is his success. In dealing with other men, it is undoubtedly what is called the personal equation that counts. Education cannot make a man, but it will develop him. Nine times out of ten it is not what a man knows, but what he is that makes the impression. No one will deny that knowledge is not absolutely essential, but it is only the power behind this knowledge which can produce the best results. We sometimes meet the unfortunate example of what has been termed the "walled-up mind" stored with facts but incapable of using them in any but a very narrow, restricted manner. For this reason a man is much better equipped who does not have to depend solely upon a technical training, no matter how good and well grounded. The breadth of view which comes from a general training has in every case its effect on those with whom we come in contact, and this in spite of the fact that those with whom we deal can very seldom put their finger on the exact reason why a strong influence is exercised.

SUGGESTED CHANGES IN THE CURRICULUM

D. J. McGUGAN, '07.

The present is marking an era of expansion for the University and this expansion, as is found to be the case with nations also, is exhibiting itself in an effort to better conditions that may be improved, wherever such opportunities may be found. The spirit of growth, with its attendant liberality of ideas, is in the air. The time is ripe for the institution of better methods and still higher ideals. But wherever any fundamental changes may be contemplated, the wisdom of making haste slowly is perceived and so any well-balanced discussion on anticipated changes can have nothing but a beneficial influence.

Dealing with our own Faculty of Applied Science more particularly, it is generally recognized that the student does not receive the full benefit of a Fourth Year. We recognize fully that one can get back only that which he puts into the Fourth Year, but whether through lack of confidence, or through lack of efficiency, it is no secret that, as at present arranged, the Fourth Year student has not the incentive to apply himself with the necessary energy to the particular branch in which he specializes. Then at the other end of our course, such a superfluity of work awaits the one of average intelligence that the only relief is found in what is familiarly termed cramming. Granted that such conditions exist, let us see how we may proceed that these difficulties may in part be remedied.

At present a large proportion of the students enter the School with Junior Matriculation. The father, understanding that such is the entrance required, and being urged on by the anxiety of the boy to enter the larger joys of college life, sends him to the School and imagines that at last the boy is safely embarked on the royal road. But any student who has entered the School under these conditions can testify how much work is represented by the First Year, with its bewildering array of mathematical and scientific subjects, all of which are, to the student, new lines of reasoning and new avenues of research. After the first glamor of boasting of all the newer branches of mathematics he is studying, has worn off, he finds much hard work ahead of him. Not that this is not a beneficial condition. Life is not all a bed of roses and the sooner a student acquires the ability of surmounting difficulties, the nearer is he to ultimate success. But since these elementary principles which are evolved in the First and Second Years form the very network on which the more advanced work and his subsequent engineering experience is built, he will, again and again, rue the fact that so much of his primary mathematics has slipped away.

As a remedy the raising of the entrance standard to Senior

Matriculation seems to suggest a very sensible and tangible relief. It will never be denied that the student can secure much more thorough training in mathematics at a collegiate institute than he can at a college, simply on account of the methods employed. Call it spoon-fed, if you will, but the fact remains that he has acquired such a grip on his mathematics that he can use the principles intelligently, and does not in an attempt to follow the mathematics involved in a lecture, lose the newer idea. Coming with this higher standard, he steps on surer ground, he attacks new branches with greater avidity and precision, and finding that all mathematics and science are an evolution, he assimilates much more of them, causing him to like the work, and liking the work, to become a greater success in it.

This standard would also bring the student nearer that age when he can appreciate the more the advantages of college associations and ideals. He has a wider view, a fuller outlook, a keener perception of the value of rubbing shoulder to shoulder with some of the cleverest and brightest men of our province. Nor is he alone benefitted. Indirectly the University receives its reward. The welfare of the College rests with the Faculty, the undergraduates and the graduates. The presence of a virile and intellectual student body must reflect itself in public opinion, and give our School a larger place in the development of our country.

Then comes the question of expense, whether is it wiser to spend an extra year at home in a collegiate or to lose a year in college where it costs much more? This of course does not apply to everybody, but the fact remains that a large number of the First Year fail every year, and I refuse to believe that the large proportion of these failures were of men who wasted so much time that success was impossible. There are examples of this, it is true, but let us not judge by isolated cases but by general conditions. It has been said that a certain number of students, any way, must fail in the First Year through lack of accommodation. Such a statement cannot be true. A pupil fails simply because he has not the requisite standing to take up subsequent work intelligently. Would it not be wiser to avoid the possibility of this by spending an extra year in the home collegiate?

It may be urged that this would bar a certain proportion of the students who come here. Perhaps it would exclude a few, to whom time and money is needful, who, by their industry, would be able to pass the First Year successfully any way, and I grant that the absence of such men would be a loss to the School. But to the general class of people, who appreciate the amount of work in the School, who are anxious to engage in engineering practice, such would be no bar, but simply a means to an end.

Then coming to the present status of the Fourth Year, mentioned briefly beforehand, the obvious remedy seems to be the

enlargement of the course to four years, thus abolishing the present standing Grad. S.P.S. The work could be more evenly distributed over the four years. More work could be added in each particular line and more irrelevant work discarded. In my mind this is the only solution of the Fourth Year problem, simply because more stress would be laid upon it by the student and he could accomplish more useful work. At present there is not sufficient work in the last year. If a student only worked at the same pressure as he did during his Third Year, the amount of work could be done in much less time.

With a four-year course, it would be well to defer too great specialization until the last year, in which year he could engage more particularly in the line of work chosen. There would be greater opportunity for continuity in the work and a common goal for all, attention being paid of course to the particular needs of each department.

This would give an opportunity for the introduction into the course of the study of English. Lectures in Rhetoric would be directly beneficial to every engineer because he is called upon to give reports, to write articles and specifications and nothing detracts more from the value of the report or the personal prestige of the writer as the improper use of the rules of grammar. In order to tone down the exactitude of the course, I should like to see the introduction of the study and reading of some of our English masters. Such would be a recreation and a rest and would be appreciated greatly in after life if a desire for the better authors was inculcated. The different details can only be arranged by men of educational experience, but it is certain that the lack of a chance to acquire a more intimate knowledge of literature is one which is felt to be a distinct loss.

Should these changes be consummated, such an opportunity of evolving well-educated, well-balanced scientific men would be at our hand, that our School might easily rank with those of greatest fame either in the Old or New World. Our graduates might not necessarily be storehouses of data and facts, but men trained to perceive, to think, to judge and to act, men whose latent capabilities have been so drawn out and developed that they would be able to take their place in the world, to which their mastery of themselves entitled them.

Where opportunities to improve the curriculum exist, where there are grievances to be ventilated, the student does not do his duty to his Alma Mater if he remains silent. Shall we then allow to pass so great an opportunity to broaden the life of the School, and in so doing, to leave our lasting imprint for good on the development and civilization of our country?

THE COURSE IN ANALYTICAL AND APPLIED CHEMISTRY

MAITLAND C. BOSWELL, M.A., Ph. D.

The course in Analytical and Applied Chemistry in the Faculty of Applied Science of the University of Toronto, has been designed to give that training in the principles of the several branches of pure and applied chemistry, viz:—Inorganic, Organic, Analytical, Engineering, Industrial and Physical Chemistry, as well as that laboratory practice in elementary chemistry, qualitative analysis, gravimetric volumetric and optical quantitative analysis, inorganic and organic synthesis, gas analysis and electro chemistry which the best university practice, both on this continent and abroad, has adopted in similar courses.

It is also the custom of the department at Toronto to supplement in the fourth year this quite universal system of lecture and laboratory work, by the consideration of special subjects, in a more detailed way than is possible during the previous three years, bearing in mind the capabilities and needs, as well as the tastes and possible future work of each student. Thus one may be particularly interested in the coal tar products, another in the destructive distillation of wood industry, another in the manufacture of sugar, another in the analysis of iron and steel, another in the synthetic preparation of dye-stuffs, or any of the large number of important organic and inorganic industries and the methods of their laboratory control. The particular subjects to be studied having been decided upon, laboratory work and reading are assigned dealing with the mechanical and chemical details of the processes involved, their analytical control, and the investigation of problems relating to these industries whose solution would be of value.

Also recognizing the fact that much of the research work performed in technical laboratories deals with subjects of purely theoretical interest, problems of this character are also assigned to students who possess the qualifications for this kind of work. Apart from the value which his research may have as a contribution to science the work of investigation is of particular advantage to the student. It seems unavoidable, owing to the immense amount of information to be assimilated, that during the major portion of the undergraduate course of the student in any branch of science, he is constantly, in his lectures, in his reading, and in his laboratory work, having poured in upon him a mass of facts, the products of other minds, with very little opportunity of developing his own powers of independent thought and originality. As a consequence we sometimes meet the unfortunate example of what has been termed "the walled up mind," stored with facts, but incapable of using them in any but a very narrow, re-

stricted manner. If the student of chemistry is to be other than a "hewer of wood and drawer of water" in his profession he must possess the power of giving expression to his stores of mechanical and chemical facts in some new form, in the solution of new problems whether they are met with in the department of pure science or applied science. Research work is one means of supplying this vital need of the student. It leads him into unknown parts, where he must think for himself and devise methods of overcoming difficulties, both mechanical and chemical. It familiarizes him with the original literature and with all the sources of information extending back to the time when chemistry began to be a science. This gives him a new point of view and causes him to assume a new attitude towards the subject as he realizes how its foundations have been laid and the superstructure raised to its present unfinished condition. Having had his patience taxed severely in overcoming the difficulties of his research he has a more sympathetic interest in the life history of the fathers of the science and a more hearty appreciation of what they accomplished.

The results of the reading and investigation are embodied in a thesis which is prescribed as partial fulfillment of the requirements for the Bachelor's degree. The titles of these theses for the present academic year are as follows:—

Mr. C. W. Graham—Laboratory methods of organic chemistry and the synthesis of Iodine derivatives.

Mr. Fux—Sugar manufacture and Analytical control.

Mr. Mason—The destructive distillation of wood.

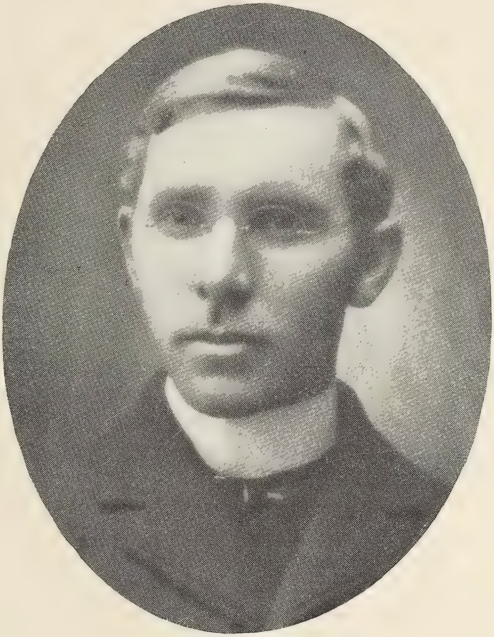
Mr. Beynon—The investigation of a new method of treating the caustic liquor form the soda process of paper manufacture.

Following is a short statement of research work being pursued by some of the advanced students. Mr. C. W. Graham is synthesizing a series of new iodine derivatives having as his objective tetraiodorthobenzoquinone and its derivatives, Mr Beynon is working on the nitrosate method for the quantitative estimation of rubber and combined sulphur in commercial rubbers and a new method for treating the caustic liquor from the soda process of paper manufacture. Mr. Fux is studying the methods of analysis used in the control of sugar manufacture. Mr. Mason is investigating some commercial products of the destructive distillation of wood of unknown composition. Mr. Huether is synthesizing typical examples of several classes of dye-stuffs and will carry out on a laboratory scale the industrial process of applying them to fibres. Mr. Rothwell is working on a new method of determining carbon monoxide. Other subjects of research which will receive early attention are—the action of stannous chloride on alpha naphthoquinone. The direct quantitative determination of oxygen in organic compounds, for which no practicable method is as yet known, a new method of estimating Phthalic acid, and methods of making some inorganic separations by means of organic reactions.

WHAT THE GRADUATES ARE DOING

Our Contributors

Charles H. Mitchell was born at Petrolea, Ontario, February 18th, 1872; and is the eldest son of Rev. George A. Mitchell, B.A., Methodist minister. He matriculated to Toronto University in 1888, graduating from the School of Practical Science in 1892. Granted post-graduate degree of B.A.Sc. (Bachelor of Applied Science) 1894; and C.E. (Civil Engineer), 1898. His career began as Assistant City Engineer at Niagara Falls, N. Y., 1892-3; engaged on special work in water-works and water-power construction and trunk sewer tunnels in rock From 1894 to 1901 he was in private practice at Niagara Falls, Canada, and during this period designed and superintended construction of the following works: Municipal — Sewer system, brick pavements, and water-works for Niagara Falls, Ontario; also bridges for County of Welland; Power Work—The hydraulic plants at Bracebridge, Fenelon Falls, Orillia, Merritton, Wahnipitae, and St. Catharines, together with minor works, and improvements to existing plants. Also made reports, plans and estimates of projected hydraulic power plants in Ontario, Quebec, Maritime Provinces and New York State. From 1901 to 1905 was Chief of Mechanical Department of the Ontario Power Company of Niagara Falls, Canada; in charge of detail, design, and construction of Civil, Hydraulic, and Mechanical portions of this famous hydro-electric installation; probably the finest in existence. In December, 1905, sailed for Europe, and during an eight months' tour, inspected critically upwards of forty Hydro-Electric plants in France, Italy, Austria, and Switzerland, also



Mr. Charles H. Mitchell

numerous steam electric power installations in Germany and Britain. Has held Captain's Commission in Canadian Militia since 1899—first in Infantry and later in Corps of Guides. And is a member of Toronto University Senate (since 1901) representing graduates in Applied Science and Engineering. In autumn of 1906 established an office in the Traders Bank Building, Toronto, as consulting engineer, specializing in Hydro-Electric Power Engineering, with its allied branches. He is engineer for several power plants in Western Canada and has lately reported on numerous works throughout the Dominion.

Among those of our graduates who have attained warked success in the field of Bridge and Structural Engineering is Mr. D. C. Tennant, B.A.Sc., A. M. Can. Soc. C. E.—a contributor to this number of APPLIED SCIENCE.

Mr. Tennant's school and college days were spent in Toronto—his native city. With the enviable distinction of a double scholarship, one granted by the Public School Board and one by the High School Board, he finished his primary school days at Ryerson and entered Harbord St. Collegiate Institute. After thorough preparation here, he enrolled at the School of Practical Science in the Department of Civil Engineering, graduating with the class of '99 and taking his degree in '00, with honors in each instance. While in the post-graduate year, Mr. Tennant made an original experimental investigation of the tensile strength of rivets and bolts which received high commendation from several prominent engineers. Though conspicuously successful as a student, he did not rest upon his well-earned laurels, but sought practical experience in every posible way. Two summers were spent in the City Engineer's Department, Toronto, and one with the New Jersey Steel and Iron Co., Trenton, N.J., on general bridge and structural work. In 1900 he entered the employ of the Dominion Bridge Co., Lachine, P. Q., actin for a short time as draughtsman and afterwards as checker and supervisor of a large section of the detailing office, which latter position he holds at present. During these eight years, Mr. Tennant has been engaged in many important works, among which might be mentioned the Fraser River Bridge at New Westminster, B.C., the Cap Rouge Trestle, described in the present issue, and many other works of considerable magnitude for the National Transcontinental Railway. Mr. Tennant is now in immediate charge of about two-thirds of the detailing office staff, being ultimately responsible for the work of some 35 draughtsmen and checkers, and in the absence of Mr. R. B. Kenrick, acting as Chief Draughtsman. With the thorough grounding of years of experience and the oft-expressed assurance of his associates that "nothing is too big or too little for Tennant to handle," we predict eminence in the engineering world for the subject of our sketch.

ENGINEERING ALUMNI DINNER

It is almost a universal rule to describe all dinners as successes, therefore in order to describe this one it must be termed an unqualified success. It was remarkable in many respects, as will be dwelt on later. The usual order of things was reversed, the dinner being merely an incident, every one being interested in the object for which it was held. It was a very informal affair, being held at 6 o'clock at the St. Charles Hotel on Thursday, March 12th.

It was the result of several small meetings held previous to the above date. All the graduates in Engineering of the University of Toronto resident in and around the city were notified and requested to attend. The business started at 7 o'clock. Mr. C. H. Mitchell, '92 Faculty Representative on the University Senate, took the chair and K. A. MacKenzie, '06, was appointed secretary. There were altogether 85 graduates present ranging from the classes of '88 up to 1907, and of the number about 35 are now in attendance in the fourth year course at the University.

The primary business of the meeting was to confirm preliminary arrangements already entered into to obtain a portrait of Dean Galbraith, to be presented to the University, and to be hung in Convocation Hall. Some time previously the consent of Dr. Galbraith was obtained and an acceptance from President Falconer was also given for the portrait when completed to hang with other similar portraits, and the preliminary arrangements were made with Mr. J. W. L. Forster, artist, of Toronto, to execute the commission.

Letters from Messrs. Stern and Alison, representing the graduates resident in New York, and Mr. Speller of those in Pittsburg, were read to the meeting, and the fact that a movement in these cities, simultaneous with that in Toronto re the portrait had taken place, was received with applause by those present.

It was thought fitting by some graduates present that some similar tribute should be made to Dr. Ellis, who has been a lifelong co-worker with Dr. Galbraith in the upbuilding of the former School of Practical Science, and what is now the Faculty of Applied Science and Engineering. Numerous suggestions were made and discussed along these lines, with the final result as embodied in the motion indicated below.

It was strongly felt by all present that a movement should be shortly inaugurated to found a Scholarship in Engineering, to be applied to research work along particular branches, and while a good many opinions were advanced, the question of ways and means, particularly at this time, seems to be the greatest obstacle. This matter was left over for consideration at a later time in the year.

The formation of an Alumni Association was discussed at length but the opinion seemed to be that such was not necessary in Toronto because of the far-reaching influence and work of the Engineering Society, and especially since its recent close connection with the Faculty itself, whereby a paid officer takes up the duties of what would be mainly the object of an Alumni Association, in keeping in touch with graduates and their work. This work is now being further extended by the monthly publication of the Applied Science Journal by the Society. Great satisfaction was displayed at the formation of an Alumni Association in New York, Pittsburg and Winnipeg and the hope expressed that others would follow.

Considerable discussion arose as to the manner in which the graduates could assist the Faculty in its new status in the University as a whole, and especially as to the efficiency of the fourth or post-graduate year. It was pointed out, however, that many improvements and additions were in immediate contemplation in this work, especially in Hydraulics and Thermodynamics, and when the new buildings and equipment as contemplated are completed, the Faculty will have one of the finest equipments on the continent. The overcrowding of the different buildings used by this Faculty is a most serious matter at the present time, there being upwards of 700 students in Applied Science and Engineering. These conditions, without adequate extension of buildings and equipment or teaching faculty, seriously decreases the efficiency and hence arises the principal criticism.

A resolution was carried unanimously appointing a committee of five,. namely, Messrs. C. H. Mitchell, '92, A. F McCallum, '93, A. E. James, '04, K. A. MacKenzie, '06, and T. H. Hogg, '07, which had already been acting, to add six others resident in Canada to their numbers, and to act in conjunction with a committee from the United States, consisting of Messrs. E. W. Stern, '84, T. Kennard Thompson, '86, T. H. Alison, '92, H. F. Ballantyne, '93, of New York, and F. N. Speller, '93, and A. R. Raymer, '84, of Pittsburg. This committee is to form a permanent committee for the year representing the graduates, and in doing so is asked to secure the portrait of Dr. Galbraith, and also to purchase some suitable gifts for personal presentation to Dr. Galbraith and Dr. Ellis. It is also asked to consider the question of scholarships, and to take means to urge the importance of research work in the Engineering Faculty along the lines suggested at the meeting. It was thought that the portrait should be presented formally to the Governors of the University at the inaugural meeting of the Engineering Society in October next, and that the other presentations should take place at a dinner to be held in Toronto shortly before Christmas next, at which as many graduates as possible from all parts of the continent should be urged to be present.

Greetings were sent from this meeting to fellow-graduates in New York, Pitsburg and Winnipeg.

It is to be noted that the enthusiasm of this meeting was very marked and that in the hour and a half consumed in speeches, twenty of the graduates present spoke, and that thirty-four speeches were made by them.

As to the probable financial arrangements suggested to be followed out by the committee, it is likely that each graduate will be asked for a subscription of $2.00. The third and fourth years of the under-graduates have guaranteed at least $100.00 through the president of the Engineering Society, an announcement of which was made by Mr. Hogg at the meeting. It is thought that the proceeds of such arrangements will be amply sufficient to provide for needs. In all between eight and nine hundred dollars will be required.

Index to Advertisers

WHEN WRITING TO ADVERTISERS YOU WILL CONFER A FAVOR ON BOTH ADVERTISER AND PUBLISHER BY MENTIONING THIS PAPER